

PROPERTIES OF THE  
"GUGLER PRIMARY BATTERY"

BY  
A. A. PERRINE

ARMOUR INSTITUTE OF TECHNOLOGY

1912

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Experimental determination  
of the properties of the

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AN EXPERIMENTAL DETERMINATION OF THE PROPERTIES

OF THE

"GUGLER PRIMARY BATTERY"

A T H E S I S

PRESENTED BY

ARTHUR A.R. PERRINE

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE

OF

ELECTRICAL ENGINEER.

MAY 1912.

Approved  
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Prof. of Elect. Eng.

X. C. McMillan  
Dean

J. M. Raymond

Dean

AN EXHIBIT STATE DEPARTMENT OF THE ARMY

OF THE

"COUNCIL OF THE ARMY"

THE ARMY

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TO THE

ARMY OF THE UNITED STATES

OF

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FOR THE ARMY

OF

ARMY OF THE UNITED STATES

MAY 1915.

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CAUTION OF INTERVIEW.



## Calibration of Instruments.

The instruments used to measure the current and voltage for these tests were Weston Volt-meter Model 45 #6093 and Weston Milli-volt meter Model 45 #5792 with one and ten amperes shunts.

It was deemed advisable to calibrate the instruments used by comparing them with a standard instrument known to be correct on account of the tendency of electrical instruments to read incorrectly after a time by reason of their construction or due to mechanical injury.

Each instrument was calibrated both before and after the test and an average value taken from the calibration curves in place of the observed readings. These average values were used in plotting curves and making calculations. The original data as read directly from the instrument was not recorded.

The calibration curves using the average values follow:









Temperature of gas + ...

157.2 ...

Thermometer ...

Voltmeter ...

Current ...

.1	.1
.2	.2
.3	.3
.4	.4
.5	.5
.6	.6
.7	.7
.8	.8
.9	.9
1.0	1.0

Temperature of gas + ...



Calibration West 10114-V

Fig. 1 - Core Plot.

Isobutane: 24.0%  
West 10114-V 10114-V  
West 10114-V 10114-V  
West 10114-V 10114-V

1.	1.
2.	1.
3.	1.
4.	1.
5.	1.
6.	1.
7.	1.
8.	1.
9.	1.
10.	1.

Temperature of 10114-V 10114-V





















Primer, 1950, p. 100.





dynamo. This great advantage is, however, somewhat balanced by the fact that the fuel consumed in the primary batteries is much more expensive than that used in steam engines. Yet while this is true for the production of large quantities of electrical energy, it is also true that for the production of smaller quantities of electrical energy the primary battery has quite an advantage in regard to economy of cost over the installation of an engine and dynamo plant.

It is the primary purpose of this investigation to bring out the more important points in the behavior of the Dryden primary battery. For this end four cells were tested, three containing sodium cells and one zinc chloride cell. In order to have the conditions of the test as near as possible to those under which the batteries are to operate in practice the electrolyte was prepared with ordinary tap water and the cells were placed in a room in which the temperature would be about normal. As the average temperature was a little low, it was assumed as could be seen readily that artificial heat and this was not deemed necessary.

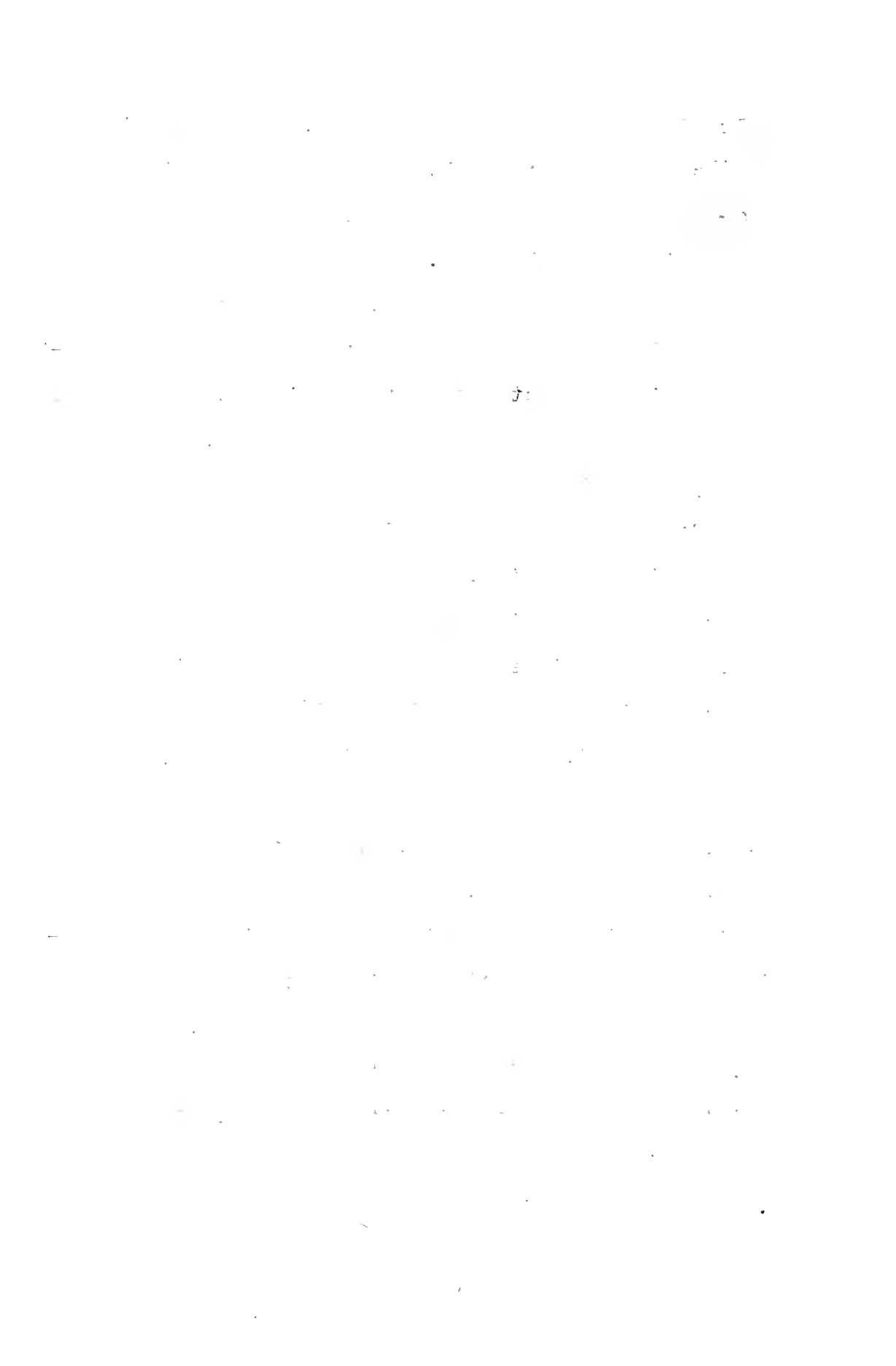
The cells submitted for the test were of temporary construction, but they were of standard design in design of our cells so that to insure the



cells will be placed in the market. The details and consist merely of a portable unit with a lar grooved bottom to receive the cells, a battery and a suitable cell cover.

The Ogler cell has not been marketed for signal service although cells of this type have been used in continuous discharge at the Western Union Telegraph Co., for more than twenty months on air charges. The report shows possibilities of using the cell in the "Blue Stone" and "Radio Cell" type of cells for use on signal service.

Before assembling the cells each part or element was carefully weighed and recorded. The weight of each cell will be found under "Weights of Cells" and "Weights of Cells". After assembling the cells, each cell was labeled and will hereafter be referred to as No. 1, No. 2, No. 3, and No. 4. At the request of Mr. Ogler, cell No. 1 was discharged through constant resistance starting at approximately twenty-five amperes by adjusting resistance to secure this after cell had been in operation for 1 hour. Cells Nos. 2 and 3 were discharged through a constant resistance in separate circuits once every ten minutes for a period of ten seconds starting at approximately 2.5 amperes which is the normal current consumption of



a saltshore. Cell No. 4 is the same as No. 3, but with sulphate or gravity cell. This cell is also to be tested to secure comparative data. The difference being through a permanent resistance and the current rate of approximately .5 amperes at the start. Each test will be explained in detail with the accompanying data and curves independently of the other tests.



HISTORY OF THE PRIMARY BATTERY.





In the year 1767 Sulzer published a paper which was read before the Academy of Sciences at Berlin, in which he announced that he had discovered that when two pieces of metal, one of gold and the other of silver are placed together upon the tongue in such a manner that their edges are in contact a peculiar taste is perceived. The importance of Sulzer's observation was not appreciated until Galvani had made his important discovery that when a prepared frog's legs when suspended by a copper wire above an iron railing, exhibited a convulsion whenever a portion of the leg touched the railing. Volta had demonstrated that this phenomenon was not due to the presence of animal tissue but due to the metals themselves. Giving rise to Volta's contact theory of electrical excitation which describes what is now known as the "difference of potential" exhibited by two metals due to a simple contact and not depending upon the medium in which they are immersed.

During the same year that Galvani's famous work appeared, Galvani described experiments which he had made with metals that he had plunged into water and said he was satisfied that a chemical action had taken place and that it was the slow combination of

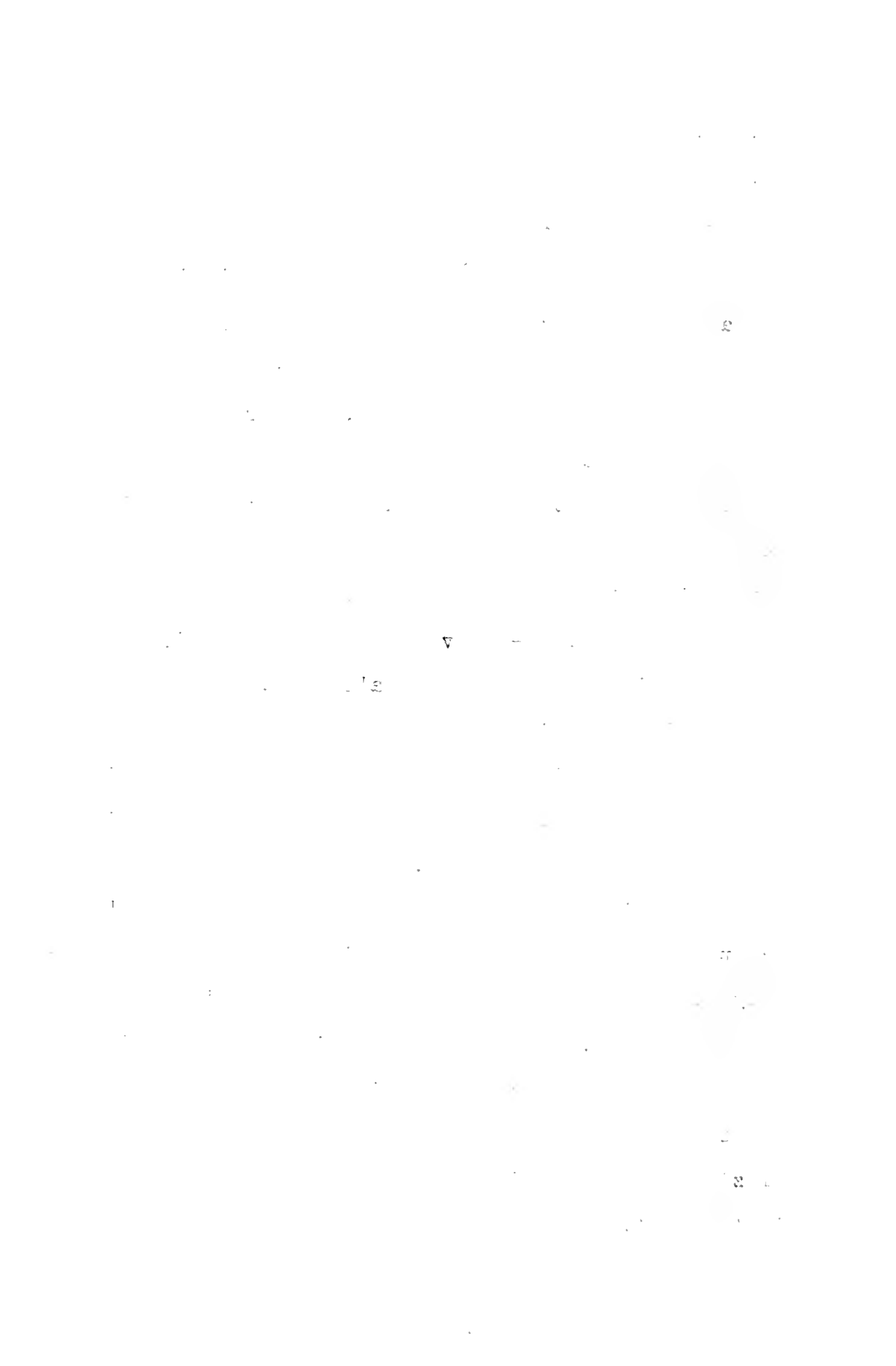


oxidation of the metal which gave rise to the electric stimulus.

The fact that the difference of potential resulting from a single pair of metals dipping into an aqueous liquid, can be thus multiplied by joining in order a number of such pairs constituted a pile, was discovered by Volta in 1800. In order to increase the effect in a marked degree, he arranged a number of alternate layers of zinc and copper; each pair of metals being separated from the next by a thin layer of acidulated water. This arrangement, which Volta called his "electro-chemical pile", but is more familiarly known as Volta's Pile.

A pile of this kind when composed of thirty or more of these pairs of plates produced a considerable physiological effect when the terminals of the pile were placed upon the tongue.

This pile led to the development of Volta's "Crown of cups" which was the first and simplest battery or device which would produce a continuous flow of electricity. This device consisted of a series of glasses or cups placed in a circle; plates of copper and zinc were connected and arranged so that a plate of zinc was placed in one cup and a plate of copper in the next.



The oldest battery of commercial importance, which does not have a depolarizer in its design, was developed in 1840. This cell had a positive plate of zinc and a negative plate of thin silver, arranged in a zig-zag pattern and covered with platinum. The purpose of this arrangement of surface was to facilitate the discharge of the cell by the oxygen which is released at the plate. The electrolyte liquid used in this cell was sulfuric acid.

Amalgamation of the zinc was introduced by Sturgeon in 1839. The two-fluid type of battery was developed with porous cup to separate the fluids and was patented by Daniell in 1836. Grove, in the same year, introduced the use of nitric acid as an electro-negative fluid more powerful than the sulfuric acid of Daniell's cell. Grove used a platinum negative plate to withstand the action of the nitric acid. In 1842 Brunner substituted carbon for this expensive metal. Poggendorf in the same year devised a single-fluid cell in which a solution of potassium bichromate mixed with sulfuric acid was used as a depolarizer instead of the nitric acid of Grove, thereby avoiding the obnoxious fumes of that material and its use in a closed cell.

Most of the batteries which have been developed since the Daniell cell were modifications of it.



form, either of its elements, it is used as the depolarizer used.

In the primary battery designed and constructed by Mr. G. Gler during the past year, a cylindrical electrode of carbon is used for the positive element surrounded by annular carbon filling most of the space in the jar outside of the carbon electrode and a cylindrical sheet of zinc placed in the jar inner. Two rounds of wire are used to connect the electrodes make contact with the negative electrode. The electrolyte used for both the outer and inner solutions was sulphuric acid.. Potassium chlorate was added to the outer solution for the depolarizer.





THEORY OF THE MOTION OF A PARTICLE.



When commercial zinc is placed in dilute sulphuric acid it is dissolved fairly rapidly and liberating hydrogen. During the time that the zinc is being dissolved considerable energy is liberated in the form of heat.

If chemically pure zinc is placed into dilute sulphuric acid very little action takes place and the small quantity of liberated hydrogen is immediately attached to the zinc plate protecting it from further action of the acid.

If a zinc plate of pure commercial zinc is placed in the solution and the plate of pure zinc is not touching, no apparent action ensues, but if wires of copper or other material are attached one to each plate, the wires being so placed as to be in contact, the action is found to differ in potential. If the wires are not connected to the terminals of a constant electrometer, a difference is indicated indicating a difference of potential of approximately one volt, the potential of the zinc plate being the greater.

Results similar to the above may be obtained if almost any two metals are used in place of the copper and zinc in the above experiment, the solution being water which contains a small quantity of sulphuric acid in solution. The only difference in the results may be in the magnitude of the potential observed.

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If now the wires are connected and the action ensues, the zinc leaf is dissolved and is rapidly liberated from the copper plate.

Closing the circuit, the generalization of the action within the electrolyte follows; to wit, that the ions of any molecule are not attached to one another but that a continual interchange of partners, as it were, takes place between different molecules. Thus, in a solution of sodium chloride, the sodium and chlorine of any molecule do not long remain attached to each other, the sodium changes place with the sodium of another molecule and the chlorine of one molecule places with the free chlorine of a third molecule. This interchange is continually going on at random as long as no outside directive force is applied. Each ion, while in the free state, bears a positive or negative charge of electricity.

If we agree with Helmholtz that the metal (or electrode) has a specific attraction for all ions, and therefore for the ions of copper, then we assume that zinc attracts a positive charge less forcibly and a negative charge more forcibly than copper does. Consequently, the plates of copper and zinc are immersed in sulphuric acid, there is no attraction of the negative ion toward the zinc.



As this interchange of ions takes place, electrons will be drawn to one or the other of the plates, where they will be deposited, until the plates have their respective charges of electricity. This action will continue until it is arrested by the repulsion of the respective charges accumulated on the plates. When an infinitesimal chemical action is commenced, and an electrical connection is made between the plates of the copper plates. Negative electricity then flows toward the copper plate and unites with the positive charge of the hydrogen atoms which causes them to leave the copper plate to meet the negative current. Thus the hydrogen gas is liberated at the copper plate. A stream of hydrogen atoms will now steadily continue in the same direction, probably by successive molecular interchanges and deliver their charges of electricity to the copper plate. This action will continue until after the external circuit is broken until the separated electric charges which cause the repulsion check the movement of the hydrogen atoms by the repulsion of like charges, and all chemical action ceases. This condition of electrical equilibrium is the condition of equilibrium. The two plates will then be found to be oppositely charged and will exhibit a difference of potential.

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The electrical action of the cell in operation is determined by the available potential energy, which is the difference in potential between the zinc and the silver-silver chloride electrode. This action is always present when the cell is used, and is due to the difference in the nature; as soon as these potentials are connected to the electrolyte, a local current is set up in the zinc, causing the zinc to be oxidized and to form pits.

To prevent this wasteful action, the zinc is amalgamated with mercury. This is accomplished by dipping the zinc into a solution of mercuric acid to remove dirt and to deposit a thin layer of mercury.

This amalgam does not prevent the zinc from being oxidized, but it prevents the local action. This amalgam of zinc with mercury does not actually prevent local action, but it reduces it to a negligible value as compared to the value the local action would have if the cell were not used.



POLARIZATION AND DEPOLARIZATION.



When a simple element, consisting of a mixture of zinc and copper in diluted sulphuric acid, is allowed to generate a current, hydrogen is evolved at the copper plate. As well as the hydrogen, hydrogen adheres to the surface of the plate giving rise to an electromotive force which opposes that of the cell. Consequently, the E. M. F. of the cell diminishes as soon as a current is generated. This decrease of potential of the cell increases with an increase of current flowing. In addition to a reduction of the E. M. F. of the cell due to the decomposition of the electrolyte, the formation of hydrogen is also objectionable in that it forms a layer on the surface of the cathode, thereby greatly increasing the internal resistance of the cell. This formation of hydrogen upon the surface of the cathode is called polarization.

The removal of this free hydrogen from the surface of the cathode by any means is called depolarization, and the removing agent, the depolarizer. It may be removed mechanically by agitating the electrolyte or by temporarily removing the cathode from the electrolyte when the cell is not in use. The chemical method is the most common method of depolarization used, and consists in placing a substance at or near the surface of the cathode with which the free hydrogen may unite, thus forming a stable



is illustrated by the following

example. Let  $\alpha = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

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Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ . 13

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ . 14

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Put  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

$$\alpha_1 + \alpha_2 + \alpha_3 = \alpha_4 + \alpha_5 + \alpha_6$$

$$\alpha_1 + \alpha_2 + \alpha_3 = \alpha_4 + \alpha_5 + \alpha_6$$

This is a system of linear equations.

Let  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Let  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Let  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

Let  $\alpha_1 = 1/2$ ,  $\alpha_2 = 1/2$ ,  $\alpha_3 = 1/2$ ,  $\alpha_4 = 1/2$ .

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DESCRIPTION OF THE CELL.



The cells tested were made by The Electrochemical Company of Minneapolis, Minnesota, and called "Gugler Primary Battery".

The cells were all of one type and consisted in brief of an outer container of glass or porcelain holding the electrolyte, deep leaden, carbon, or copper cylinder, granular carbon, surrounding the inner porous cup. This porous cup contains the zinc element with its terminal contact being made between the terminal and zinc by means of a separator. The cup is filled to one-half inch of the top with the same electrolyte as was used in the outer containing jar.

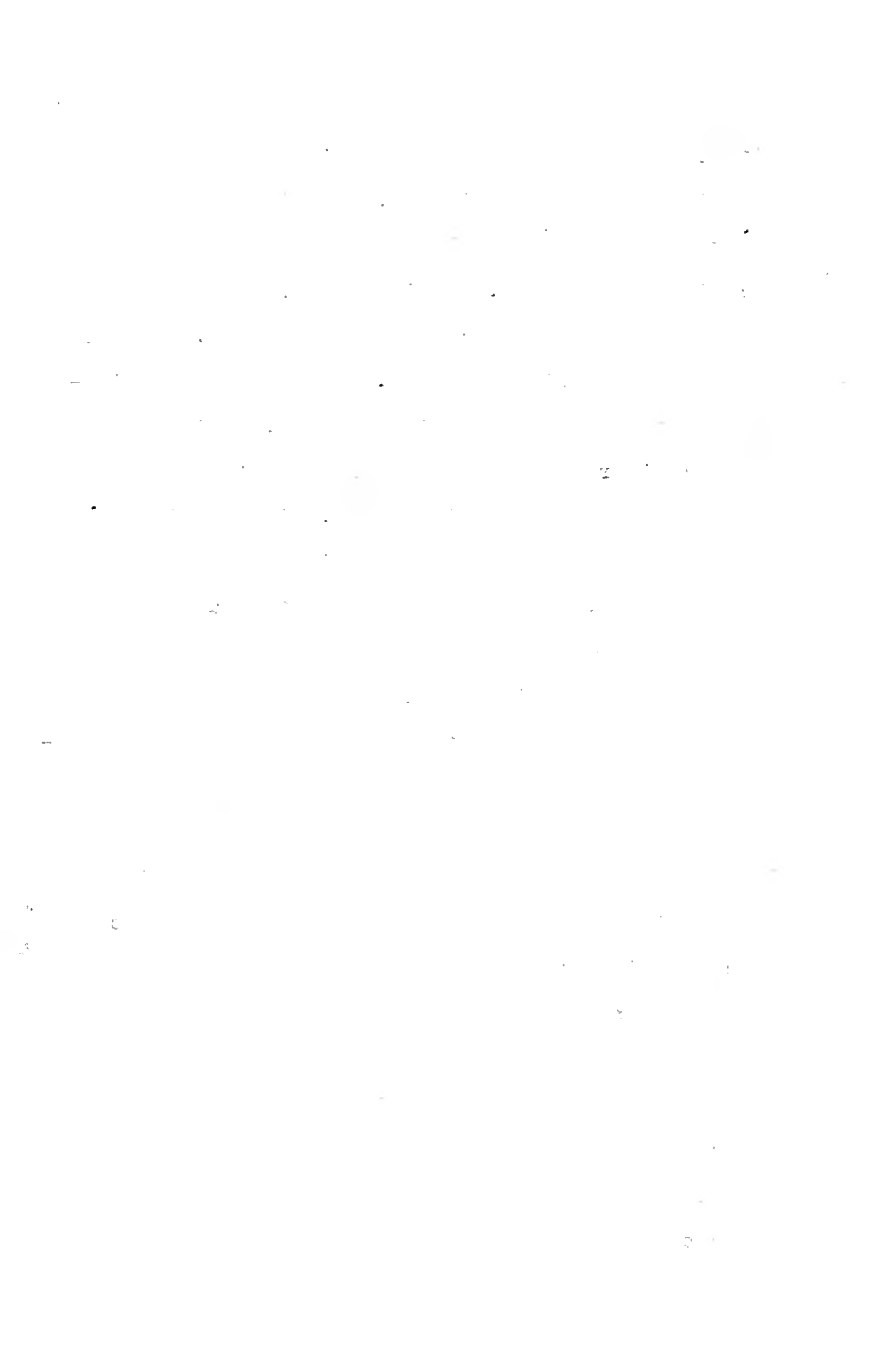
The different parts entering into each completed cell were as near a duplicate of each other as they could be commercially made. The weight of the parts entering into the construction of the cells is related for a 100 cell order "Weights of Parts Composing Cells".

The glass containing jar was 9.7 inches in diameter and 11.375 inches high and made of a material approximately .21 of an inch thick. The bottom of the jar at one point is formed into a .25 inch flat so that all the electrolyte will drain down into this



little pocket as the cell is drained. The total capacity of the glass is 595.54 cubic inches and the volume of a vertical section of the jar one inch in height is 59.7 cubic inches.

The large carbon cylinder used was 1.75 inches high and had a diameter of 4.25 inches. The thickness of the material forming it was .475 inches. A small cylindrical projection from the top of carbon of a diameter of approximately 1.5 inches with a reduced diameter at its top forming a shoulder forms a contact lug. In this reduced portion a metal cup is cast of an expanding alloy which firmly binds the carbon in cooling. Over the metal cup a glass cap is placed which rests on the shoulder of the carbon lug and is made tight with a compound between the glass and carbon joint. The glass cap is larger internally than the metal cup and this space is filled with a mineral oil which effectually prevents osmotic electrolysis between the carbon and metal couple. The glass cap has an axial perforation with a rounded boss. On top of this boss another glass cap is placed in an inverted position forming a cup. Through this glass cup and cap a sleeve connector with a threaded stud on one end is passed and is drawn down tight by screwing in a threaded hole in the metal cup. The



abutting. The ...  
... is required to ...  
... reported only ...  
... is filled with oil ...  
... carbon electrode ...  
... against corrosion.

After insertion ...  
... eter and ...  
... bottom of the ...  
... between the surface of the ...  
... trole is filled with ...  
... side from the ...  
... in a mesh of .05 inch ...  
... degrees ...  
... the ...

The ...  
... .180 inches ...  
... 12.75 inches ...  
...  
... electrode ...  
... into the ...  
... filled ...  
... the ...  
... the ...  
... water.





The zinc electrode of the cell is a cylinder 7.75 inches high and 3.5 inches in diameter. It is formed by rolling from a flat plate which is approximately one half inch in thickness of the cylinder.

The cell is set up in the following manner. After washing the glass jar, zinc wire is placed in it to remove dirt or other impurities, and the carbon cylinder is placed in the glass containing jar. The glass tube for draining off the water solution is inserted in the pocket of the glass jar, then the remaining space between the carbon cylinder and the glass jar is filled with granular carbon which has a approximate size of .85 inches, until an even distance of 3.7 inches is secured, then about 2 inches of granular carbon having a size of about .475 inches is added. One pound of potassium chloride is then placed in the jar of the granular carbon.

The porous cup was placed in the center of the carbon cylinder, and the electrolyte solution was poured into it. The zinc electrode is placed in the cup.

In order to make the test cell operation as near as possible to that that will be in practice



ordinary tap water added to the electrolyte. To a known quantity of electrolyte chemically pure sodium hydroxide is added until the specific gravity of the solution is 1.115 at a temperature of 70° Fahrenheit is secured. A portion of this electrolyte is then poured into the glass cell to a depth of .5 inches from the top of the cell. The weight of this solution is determined by subtracting the weight of the containing jar from the original weight. Additional electrolyte is then poured into the cell around the carbon element, until it is .5 inches from the top of the edge of the cell. The weight of this outer solution is determined as before. The weight of the electrolyte in the cell was thus determined.

The cell was allowed to stand at room temperature for ten hours before being used. To determine the effect of the electrolyte on the cell, the cell was allowed to stand at room temperature for ten hours before being used. The cell was then placed in a water bath at 70° Fahrenheit or 21.1° Celsius. The cell was then connected to a voltmeter and the voltage was read. The voltage of the cells immediately after assembling was .10 volts and after 10 minutes the value of the voltage was .10 to .15 volts.



The reason that the voltage did not reach the theoretical value was probably partly due to the fact that the temperature was rather low.

The cell may be recharged by syphoning the electrolyte solution off and adding a new solution having a density two degrees higher than the original solution in order to compensate for the water left in the receptacle from the previous solution. The syphoning apparatus consists of two lengths of rubber tubing connected by a rubber bulb. One of the free ends of the apparatus is to be placed in the liquid to be syphoned and the other end in the receptacle into which the liquid is to be transferred. The receptacle being below the top of the electrolyte the flow can be started by compressing the bulb. When the opening below the bulb and allowing the bulb to expand, and the liquid is to be forced over into the bulb. When the bulb is released the electrolyte will continue to flow until all the liquid is transferred or air enters the open end of the tube destroying the vacuum.



WEIGHTS OF MATERIALS.

DEPARTMENT OF MINISTRY



Weights of Component Parts of Cell Number One.

Glass jar,	6.798	Lbs.
Zinc,	4.05875	"
Porous cup, #53S,	1.773	"
Carbon terminal,	6.383	"
Gass syphoning tube,	.0743	"
Granular carbon,	3.582	"
Mercury.	2.	"
Potassium chlorate,	1.	"
Contact rod to zinc terminal	.219	"
Outer solution,	6.355	"
Solution in porous cup,	3.847	"
<hr/>		
Total weight,	36.09005	"
Weight of zinc plus mercury		
after test,	5.688	"

after test, 2.682  
Weight of zinc plus mercury

Total weight, 36.0005  
Solution in porous cup, 3.847  
Outer solution, 6.358

Contact rod to zinc terminal . 219  
Potassium chloride, 1.  
Mercury, 2.

Granular carbon, 3.582  
Gas absorbing tube, .0743  
Carbon terminal, 6.382  
Porous cup, #232, 1.773  
Zinc, 4.0512

Glass jar, 6.798 lbs.

Weights of Component Parts of Cell Number One.

# Weights of Component Parts of Cell Number Two.

Glass jar,	6.907	Lbs.
Zinc,	4.0625	"
Porous cup,	1.626	"
Carbon terminal,	6.477	"
Glass syphoning tube,	.0743	"
Grannular carbon,	4.1543	"
Mercury,	2.	"
Potassium chlorate,	1.	"
Contact rod to zinc terminal,	.219	"
Outer solution,	7.237	"
Solution in porous cup,	3.106	"
<hr/>		
Total weight,	36.8631	"

Weight of zinc plus mercury

after test,	5.663	"
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# Weights of Component Parts of Cell Number Two.

0.007	Glass jar.
0.002	Zinc.
1.036	Porous cup.
0.447	Carbon terminal.
0.043	Glass siphoning tube.
4.143	Granular carbon.
3.	Mercury.
1.	Potassium chloride.
0.519	Contact rod to zinc terminal.
0.037	Outer solution.
0.106	Solution in porous cup.
86.8631	Total weight.

Weight of zinc plate removed

after test. 0.003

# Weights of Component Parts of Cell Number Threes.

Glass jar,	6.682	Lbs.
Zinc,	4.0625	"
Porous cup. S50,	1.860	"
Carbon terminal,	6.688	"
Glass syphoning tube,	.0743	"
Granular carbon,	3.893	"
Mercury,	2.	"
Potassium chlorate,	1.	"
Contact rod to zinc terminal,	.219	"
Outer solution,	6.739	"
Solution in porous cup,	3.536	"
Total weight,	36.6538	"
Weight of zinc plus mercury after test,	5.663	"

[illegible]

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

Page 4

100 1000 10000 100000

[illegible][illegible]

99 . . . . .

[illegible]

1. . . . .

7. *Anticardiolipin antibodies* (ACA) were measured by a modified enzyme-linked immunosorbent assay (ELISA) [10].

10-10-68

8827.38

"I will not be a 'dope'."

709.5      , 1967 edition

Weights of Component Parts of Cell Number Four.

Glass jar,	3.356	Lbs.
Zinc terminal,	3.992	"
Copper terminal,	.1211	"
Copper sulphate,	1.5	"
Weight of water,	7.265	"
<hr/>		
Total weight,	16.2341	"
Weight of zinc after test	2.52	"

Weights of Component parts of the Number 100.

Lead	2.00	Weight
"	1.00	Terminal
"	1.00	Coil
"	1.00	Coil
"	1.00	Coil
"	1.00	Coil
<hr/>		
"	1.00	Coil
"	1.00	Coil

Weight of this after test



P A R T I.

T E S T NO. I.

DISCHARGING AT A CONSTANT RATE.

DISCHARGING AT A CONSTANT RATE.  
T F B T NO. 1.  
I T H A C

F I G U R E I.

A SCHEME OF THE CONNECTIONS USED  
IN MAKING THE TESTS.



## T E S T   N O .   I .

The apparatus used in performing the tests, other than the batteries, consisted of the following:

- (1) 0-3 Direct current, direct reading Weston volt meter.
- (2) 0-100 Milli-volt meter and ampere shunts for 1 and 10 amperes.
- (3) Coil resistances and wire.
- (4) 3 Double pole, double throw switches.
- (5) 3 Single pole, single throw switches.
- (6) 1 Three pole double throw switch.
- (7) 6 Volt storage battery.
- (8) Clock with second-hand attachment.
- (9) 2 Auxiliary relay coils.
- (10) 1 Contact counter.

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- (5) 3 Single pole, single throw switches.
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- (7) 6 Volt storage battery.
- (8) Clock with second-hand attachment.
- (9) 2 Auxiliary relay coils.
- (10) 1 Contact counter.







The apparatus was connected according to the scheme shown in Figure 1. Battery #1 was connected in series with switch #2, and resistance  $r_1$ , now by throwing switch #7 to the left, the closed circuit voltage may be read on voltmeter V, and by opening switch #2 the open circuit voltage may be read. The current of cell #1 was determined by throwing switch #3 to the left and opening switch #2.

Cell #2 was connected with a counting relay, auxiliary relay contact, switch #1, and resistance  $r_2$  in series. By throwing switch #4 to the left and opening switch #1, the current may be read on ammeter  $A_2$ . The voltage can be read by throwing switch #6 to the left.

Cell #3 was connected through a switch #7, resistance  $r_3$  and an auxiliary relay.(contact). The current was determined by throwing switch #4 to the right and opening switch #3. The voltage being read by throwing switch #6 to the right.

Readings of battery #4 were determined by inserting the ammeter shunt  $A_1$  in the circuit, and connecting the Voltmeter across the terminals.

On the data sheets "I" is the current in amperes:  $E_1$  is the closed circuit voltage:  $E_0$  is the open circuit voltage: D is the density in degrees Baume: and "r" is the resistance of the cell.

The apparatus was connected according to the scheme

shown in Figure 1. Battery #1 was connected in series with switch #3, and resistance  $R_3$ , now by throwing switch #3 to the left, the closed circuit voltage may be read on voltmeter V, and by opening switch #3 the open circuit voltage may be read. The current of cell #1 was determined by throwing switch #3 to the left and reading switch #2.

Cell #2 was connected with a coil, a relay, and a switch #4, and resistance  $R_4$  in series. By throwing switch #4 to the left and opening switch #4, the current may be read on ammeter A. The voltage can be read by throwing switch #4 to the left.

Cell #3 was connected through a switch #5, resistance  $R_5$ , and an auxiliary relay, contact. The current was determined by throwing switch #5 to the right and opening switch #5. The voltage may be read by throwing switch #5 to the right.

Resistances of cell #4 were determined by in-

serting the resistor and  $A_1$  in the circuit, and connecting the voltmeter across the terminals.

On the other hand "I" is the current in the circuit

$E_1$  is the closed circuit voltage;  $R_1$  is the open circuit voltage;  $R$  is the resistance in the circuit; and "r" is the resistance of the cell.

The value of "r" is determined from the known values of  $E_1$ ,  $E_2$ , and I by use of the formula,

$$r = \frac{E_2 - E_1}{I}$$

The temperature, density, current, open and closed circuit voltage was determined every eight hours for a period of 560 hours. In test # 1, the cell was discharged through a fixed resistance at an average rate of .2097 amperes. The average potential applied being 1.554 volts. The circuit was disturbed but momentarily when the readings were taken.

Curves for each of the cells tested were plotted showing the relation between amperes, volts, temperature and time in hours. Care was used in plotting the curves, they being secured by plotting from point to point and the average value of the ordinates determined by the use of a planimeter.

#### Calculations and Results.

It will be noticed from a consideration of the data, that the resistance of cell # 1 increased from .1571 to .246 ohms, and that the value was affected slightly by temperature.

Knowing the average voltage and current per cell, the watts output may be calculated from the formula:

$$W = E_1 I$$

The value of "r" is determined by the known

value of  $E_1$ ,  $E_2$ , and  $I$  by use of the formula,

$$r = \frac{E_1 - E_2}{I}$$

The temperature, density, current, and area of coil

circuits voltage was determined every eight hours  
for a period of 880 hours. In test #1, the coil was

discharged through a fixed resistance of 10 ohms  
and 0.007 ampere. The average potential applied

being 1.714 volts. The circuit was discharged at

normality when the readings were taken.

After the test of the coil, tested was plotted

showing the relation between ampere, voltage, and  
and time in hours. Data was used in plotting the

curves, only being secured by plotting the points  
and the average value of the original test data

by the use of a planimeter.

Calculations and results.

It will be noticed from a consideration of the

data, that the resistance of coil #1 increased from

1571 to 2846 ohms, and that the value was constant

slightly by temperature.

Knowing the average voltage and current per coil,

the water output may be calculated from the formula:

$$W = \frac{E_1}{I}$$

and knowing the total number of hours the cells were discharged, the total watt-hours per cell may be determined by the use of the formula:

$$W^1 = E I t$$

in which  $W^1$  equals output in watt-hours, and  $t$  is total time in hours.

Both the inner and outer solutions, in this test had a density of 15<sup>0</sup> Baume at 70<sup>0</sup> Fahrenheit.

weight of zinc+ Hg before test = 6.05875

weight of zinc+ Hg after test = 5.707

weight of zinc consumed = .35175# or 160 grams.

The area of the ampere-hour curve = 22.22 sq. in.  
1 sq. in. = 4 ampere-hours giving 116.88 ampere-hours  
giving an average  $I$  of .2097 or ampere-hours output =  
.2097 x 560 = 116.88.

Theoretical loss = 116.88 x 3600 x .000336 =  
141.5 grammes of zinc, in which 3600 is a conversion  
factor for changing ampere-hours into coulombs, namely  
amperes per second, and .000336 is the electro-chemical  
equivalent of zinc.

Therefore 18.5 grammes are consumed by local action  
and the efficiency is  $141.5 \div 160$  or 88.5 %.

and knowing the total number of hours the cells were discharged, the total watt-hours per cell may be determined by the use of the formula:

$$W = E \cdot I \cdot t$$

in which W equals output in watt-hours, and E is total time in hours.

Both the inner and outer solutions, in this test had a density of 1.200 at 70° Fahrenheit.

Weight of zinc - before test = 6.0387g

Weight of zinc - after test = 5.709g

Weight of zinc consumed = .3297g or 150 grains.

The area of the ampere-hour curve = 2.38 ad. in.

I ad. in. = 4 ampere-hours giving 116.88 ampere-hours

giving an average I of .9097 or ampere-hours output =

$$.9097 \times 129 = 116.88$$

$$\text{Theoretical loss} = 116.88 \times 3600 \times .000356 =$$

141.5 grams of zinc, in which 3600 is a conversion

factor for changing ampere-hours into coulombs, namely

ampere per second, and .000356 is the electro-chemical

equivalent of zinc.

Therefore 141.5 grams are consumed by local action.

and the efficiency is  $141.5 \div 160$  or 88.5 %.

## Cost of Materials

### Cell # 1.

Weight of outer solution = 6.355 lbs.

Weight of cup solution = 3.847 lbs.

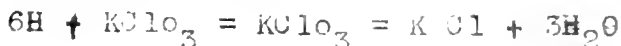
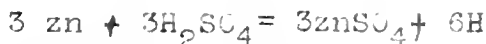
Total weight of solution = 10.202 lbs.

Since density of acid = 15° Baume = 1.116 sp. gr.  
 wt. of 1.116 sp. gr. solution per cu. ft. = 69.6022,  
 per cent of acid in 1.116 sp. gr. solution = 15.904,  
 therefore weight of actual acid in solution = 10.202  
 lbs. x .15904 = 1.61 lbs.

As the cells were not completely exhausted, the  
 chemical equivalent of material used would be as  
 follows:  $\text{H}_2\text{SO}_4$  consumed equals atomic wt. of  $\text{H}_2\text{SO}_4$   
 $\div \frac{97.92}{64.82} = 1.509.$

The actual consumption of 100% acid equals  
 1.509 x .35175 lbs. zn. = .565 lbs. of acid.  
 The commercial acid consumed equals .565  $\div$  .96  
 = .589 lbs. commercial acid consumed. Then at  
 1.5 cents per pound, the acid used would cost .884 Cents

The  $\text{KClO}_3$  consumed would be determined as follows:  
 since one molecule of  $\text{KClO}_3$  combines with six molecules  
 of H and as,



# Cost of Materials

Cell # 1.

Weight of outer solution = 6.332 lbs.  
 Weight of top solution = 3.847 lbs.  
 Total weight of solution = 10.179 lbs.

Since density of acid = 1.85 gms = 1.16 sp. gr.  
 wt. of 1.16 sp. gr. solution per cu. ft. = 69.6082,  
 per cent of acid in 1.16 sp. gr. solution = 15.30,  
 therefore weight of actual acid in solution = 10.179  
 lbs. x .15304 = 1.561 lbs.

As the cells were not completely exhausted, the  
 chemical equivalent of material used would be an  
 follows:  $H_2SO_4$  consumed equals at this wt. of  $H_2SO_4$

$$\frac{.97.92}{.61.92} = 1.583.$$

The actual consumption of 100% acid equals

$$1.583 \times .3715 \text{ lbs. cu.} = .586 \text{ lbs. of acid.}$$

The commercial acid consumed equals  $.586 \div .96$

$$= .610 \text{ lbs. commercial acid consumed. Then at}$$

1.5 cents per pound, the acid cost would cost .0915 cents

The  $K_2Cr_2O_7$  consumed would be determined as follows:

since one molecule of  $K_2Cr_2O_7$  combines with six molecules

of H and as,

$$3 \text{ H} + 2 \text{K}_2\text{Cr}_2\text{O}_7 = \text{K}_2\text{Cr}_2\text{O}_7 + 3 \text{H}_2\text{O}$$

$$6 \text{H} + \text{K}_2\text{Cr}_2\text{O}_7 = \text{K}_2\text{Cr}_2\text{O}_7 + 3 \text{H}_2\text{O}$$



therefore atomic weight of  $\text{K ClO}_3 \div$  atomic wt. of  $\text{H}_2\text{SO}_4$  will equal amount of  $\text{K ClO}_3$  required or,  $122.22 \div 293.70 = .418$  times actual acid used, or  $.418 \times .589 = .246$  lbs  $\text{K ClO}_3$ , and since  $\text{K ClO}_3$  costs 9.5 cents per pound, the amount consumed would cost 2.318 cents.

Zinc consumed = .35175 lbs. and costs at 8.5 cents per pound, 3 cents.

The total cost of the material used in the cell when the average voltage of cell was 1.554 volts, and the average current was .209 amperes for 560 hrs. giving 181.2 watt-hours, was as follows: assuming the available chemical efficiency as 80% for the  $\text{H}_2\text{SO}_4$  and  $\text{K ClO}_3$  would be 7.02 cents.

The cost per K.W. hr. output would be 38.7 cts. The foregoing cost shows the possible minimum of commercial cost per K.W.hr. based upon a chemical efficiency of 80% which seems to have been obtained on complete discharge tests.

therefore atomic weight of  $KClO_3$  - atomic wt. of  $H_2SO_4$   
 will equal amount of  $KClO_3$  required or,  $123.26 - 325.70$   
 = .418 times actual acid used, or,  $.418 \times .583 = .243$  lbs  
 $KClO_3$ , and since  $KClO_3$  costs 2.5 cents per pound, the  
 amount consumed would cost 2.318 cents.  
 Zinc consumed = .35178 lbs. and costs at 2.5 cents  
 per pound, 3 cents.  
 The total cost of the material used in the cell  
 when the average voltage of cell was 1.554 volts,  
 and the average current was .209 amperes for 560 hrs.  
 giving 181.3 watt-hours, was as follows: assuming  
 the available chemical efficiency as 80% for the  
 $H_2SO_4$  and  $KClO_3$  would be 7.08 cents.  
 The cost per K.W. hr. output would be 28.7 cts.  
 The foregoing cost shows the possible minimum of com-  
 plete discharge costs.  
 Total cost per K.W. hr. based upon a chemical eff-  
 iciency of 80% which seems to have been obtained on

C E L L N O . I .

Time	E 1	E 2	I	Density	r.	Hrs.
2 AM		.16	0	15		
2 PM		1.832		16.0		
10	1.723	1.766	.21	16.2	.1571	8
6 AM	1.70	1.734	.22	16.4	.1545	16
2 PM	1.73	1.765	.225	16.5	.1555	24
10	1.74	1.776	.21	16.45	.171	32
6 AM	1.66	1.706	.215	16.8	.168	40
2	1.63	1.666	.21	16.9	.171	48
10	1.594	1.63	.199	17.	.181	56
6 AM	1.587	1.620	.20	17.1	.180	64
2 PM	1.58	1.618	.205	17.4	.186	72
	6 oz. H <sub>2</sub> O added					
10	1.594	1.63	.21	15.9	.171	80
6 AM	1.574	1.61	.203	16.5	.177	88
2 PM	1.572	1.61	.203	17.5	.187	96
10	1.656	1.695	.215	17.4	.181	104
6 AM	1.547	1.586	.215	17.4	.183	112
2 PM	1.555	1.596	.2151	17.5	.199	120
10	1.536	1.576	.205	18.	.197	128
6 AM	1.600	1.639	.209	17.8	.186	136
	6 oz. H <sub>2</sub> O added					

# U. S. N. A. S.

Time	Lat	Long	Alt	Wind	Temp	Pressure
8 AM	10.0	10.0	10.0	10.0	10.0	10.0
9 AM	10.0	10.0	10.0	10.0	10.0	10.0
10 AM	10.0	10.0	10.0	10.0	10.0	10.0
11 AM	10.0	10.0	10.0	10.0	10.0	10.0
12 PM	10.0	10.0	10.0	10.0	10.0	10.0
1 PM	10.0	10.0	10.0	10.0	10.0	10.0
2 PM	10.0	10.0	10.0	10.0	10.0	10.0
3 PM	10.0	10.0	10.0	10.0	10.0	10.0
4 PM	10.0	10.0	10.0	10.0	10.0	10.0
5 PM	10.0	10.0	10.0	10.0	10.0	10.0
6 PM	10.0	10.0	10.0	10.0	10.0	10.0
7 PM	10.0	10.0	10.0	10.0	10.0	10.0
8 PM	10.0	10.0	10.0	10.0	10.0	10.0
9 PM	10.0	10.0	10.0	10.0	10.0	10.0
10 PM	10.0	10.0	10.0	10.0	10.0	10.0
11 PM	10.0	10.0	10.0	10.0	10.0	10.0
12 AM	10.0	10.0	10.0	10.0	10.0	10.0
1 AM	10.0	10.0	10.0	10.0	10.0	10.0
2 AM	10.0	10.0	10.0	10.0	10.0	10.0
3 AM	10.0	10.0	10.0	10.0	10.0	10.0
4 AM	10.0	10.0	10.0	10.0	10.0	10.0
5 AM	10.0	10.0	10.0	10.0	10.0	10.0
6 AM	10.0	10.0	10.0	10.0	10.0	10.0
7 AM	10.0	10.0	10.0	10.0	10.0	10.0
8 AM	10.0	10.0	10.0	10.0	10.0	10.0

C E L L N O . I .

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 PM	1.62	1.658	.22	15.	.175	144
10	1.598	1.646	.22	16.	.177	152
6 AM	1.566	1.606	.21	17.7	.190	160
2 PM	1.57	1.61	.212	17.7	.188	168
10	1.576	1.616	.212	17.7	.194	176
6 AM	1.576	1.617	.22	17.5	.186	184
2 PM	1.581	1.618	.219	17.	.169	192
10	1.584	1.626	.216	17.5	.194	200
6 AM	1.605	1.646	.219	18.	.187	208
	6 oz. H <sub>2</sub> O added					
2 PM	1.588	1.628	.218	16.3	.185	216
10	1.585	1.626	.218	16.3	.186	224
6 AM	1.585	1.626	.212	17.2	.196	232
2 PM	1.582	1.623	.213	17.2	.195	240
10	1.569	1.61	.208	17.5	.197	248
6 AM	1.51	1.551	.208	18.	.197	256
2 PM	1.534	1.575	.21	19.	.195	264
10	1.535	1.576	.211	19.1	.194	272
6 AM	1.524	1.565	.21	19.5	.197	280

TABLE 1

Year	Age	Gender	Sex	Age	Sex	Year
1941	271.	181	SS.	1.000	1.000	MA 3
1942	271.	181	SS.	1.000	1.000	IO
1943	271.	181	SS.	1.000	1.000	MA 3
1944	271.	181	SS.	1.000	1.000	IO
1945	271.	181	SS.	1.000	1.000	MA 3
1946	271.	181	SS.	1.000	1.000	IO
1947	271.	181	SS.	1.000	1.000	MA 3
1948	271.	181	SS.	1.000	1.000	IO
1949	271.	181	SS.	1.000	1.000	MA 3
1950	271.	181	SS.	1.000	1.000	IO
1951	271.	181	SS.	1.000	1.000	MA 3
1952	271.	181	SS.	1.000	1.000	IO
1953	271.	181	SS.	1.000	1.000	MA 3
1954	271.	181	SS.	1.000	1.000	IO
1955	271.	181	SS.	1.000	1.000	MA 3
1956	271.	181	SS.	1.000	1.000	IO
1957	271.	181	SS.	1.000	1.000	MA 3
1958	271.	181	SS.	1.000	1.000	IO
1959	271.	181	SS.	1.000	1.000	MA 3
1960	271.	181	SS.	1.000	1.000	IO

C E L L NO. I.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 PM	1.541	1.583	.213	20.	.209	288
10	1.54	1.582	.213	20.	.208	296
6 AM	1.524	1.566	.2	20.1	.21	304
2 PM	1.534	1.576	.2	20.2	.21	<b>312</b>
10	1.525	1.57	.21	20.8	.208	320
6 AM	1.518	1.56	.2	20.9	.21	328
	6 oz. H <sub>2</sub> O added					
2 PM	1.557	1.570	.208		.207	336
10	1.52	1.563	.202	21.7	.213	344
6 AM	1.526	1.569	.203	21.	.216	352
2 PM	1.534	1.577	.208	20.7	.207	360
10	1.527	1.57	.208	21.	.207	368
6 AM	1.517	1.569	.212	21.5	.203	376
2 PM	1.516	1.558	.208	22.	.202	384
10	1.518	1.56	.203	22.1	.207	392
6 AM	1.503	1.546	.209	22.5	.206	400
2 PM	1.502	1.546	.209	22.5	.211	408
10	1.514	1.558	.21	22.8	.209	416
6 AM	1.486	1.53	.208	22.9	.216	424
2 PM	1.53	1.566	.208	23.	.208	432

Time	M I	E S	I	Demet- ty	r	Mr.
2 PM	1.541	1.583	.213	.30	.303	388
10	1.54	1.583	.213	.30	.308	389
6 AM	1.584	1.586	.2	.30.1	.21	394
2 PM	1.534	1.576	.2	.30.3	.21	313
10	1.525	1.57	.21	.30.3	.308	380
6 AM	1.518	1.56	.2	.30.2	.21	388
	6.02	1.50				
2 PM	1.537	1.570	.303		.21	336
10	1.53	1.563	.303	.21.7	.213	344
6 AM	1.536	1.569	.303	.21	.216	333
2 PM	1.534	1.577	.308	.30.7	.307	380
10	1.537	1.57	.308	.21	.307	388
6 AM	1.517	1.563	.213	.21.5	.303	379
2 PM	1.516	1.558	.308	.23	.303	384
10	1.513	1.56	.303	.23.1	.307	383
6 AM	1.503	1.546	.303	.23.3	.303	400
2 PM	1.503	1.545	.303	.23.3	.211	408
10	1.514	1.558	.21	.23.8	.303	416
6 AM	1.486	1.53	.303	.23.7	.216	434
2 PM	1.53	1.566	.308	.23	.308	433



C E L L N O . I .

Time	E 1	E 2	I	Densi- ty	r	Hrs
10 PM	1.52	1.566	.209	23.	.206	440
6 AM	1.524	1.558	.211	23.5	.208	448
2 PM	1.511	1.556	.21	24.	.214	456
10 PM	1.505	1.545	.21	23.9	.214	464
6 AM	1.515	1.560	.209	24.1	.215	472
2 PM	1.486	1.532	.213	24.	.216	480
	6 oz. H <sub>2</sub> O added					
10	1.476	1.523	.21	22.5	.222	488
6 AM	1.52	1.566	.212	22.8	.217	496
2 PM	1.52	1.566	.21	23.1	.219	504
10	1.524	1.57	.21	23.2	.219	512
6 AM	1.490	1.536	.211	24.	.218	520
2 PM	1.50	1.546	.218	24.2	.224	528
10 PM	1.476	1.52	.2	24.5	.21	536
6 AM	1.51	1.557	.205	24.1	.229	544
2 PM	1.52	1.57	.203	24.8	.246	552
10 P.M.	1.47	1.52	.205	25.	.24	560

Time	1	2	3	4	5	6
10 PM	1.180	1.180	1.180	1.180	1.180	1.180
9 PM	1.184	1.184	1.184	1.184	1.184	1.184
8 PM	1.181	1.181	1.181	1.181	1.181	1.181
7 PM	1.185	1.185	1.185	1.185	1.185	1.185
6 PM	1.180	1.180	1.180	1.180	1.180	1.180
5 PM	1.184	1.184	1.184	1.184	1.184	1.184
4 PM	1.188	1.188	1.188	1.188	1.188	1.188
3 PM	1.184	1.184	1.184	1.184	1.184	1.184
2 PM	1.188	1.188	1.188	1.188	1.188	1.188
1 PM	1.184	1.184	1.184	1.184	1.184	1.184
12 PM	1.188	1.188	1.188	1.188	1.188	1.188
11 AM	1.184	1.184	1.184	1.184	1.184	1.184
10 AM	1.188	1.188	1.188	1.188	1.188	1.188
9 AM	1.184	1.184	1.184	1.184	1.184	1.184
8 AM	1.188	1.188	1.188	1.188	1.188	1.188
7 AM	1.184	1.184	1.184	1.184	1.184	1.184
6 AM	1.188	1.188	1.188	1.188	1.188	1.188
5 AM	1.184	1.184	1.184	1.184	1.184	1.184
4 AM	1.188	1.188	1.188	1.188	1.188	1.188
3 AM	1.184	1.184	1.184	1.184	1.184	1.184
2 AM	1.188	1.188	1.188	1.188	1.188	1.188
1 AM	1.184	1.184	1.184	1.184	1.184	1.184
12 AM	1.188	1.188	1.188	1.188	1.188	1.188

[illegible][illegible]

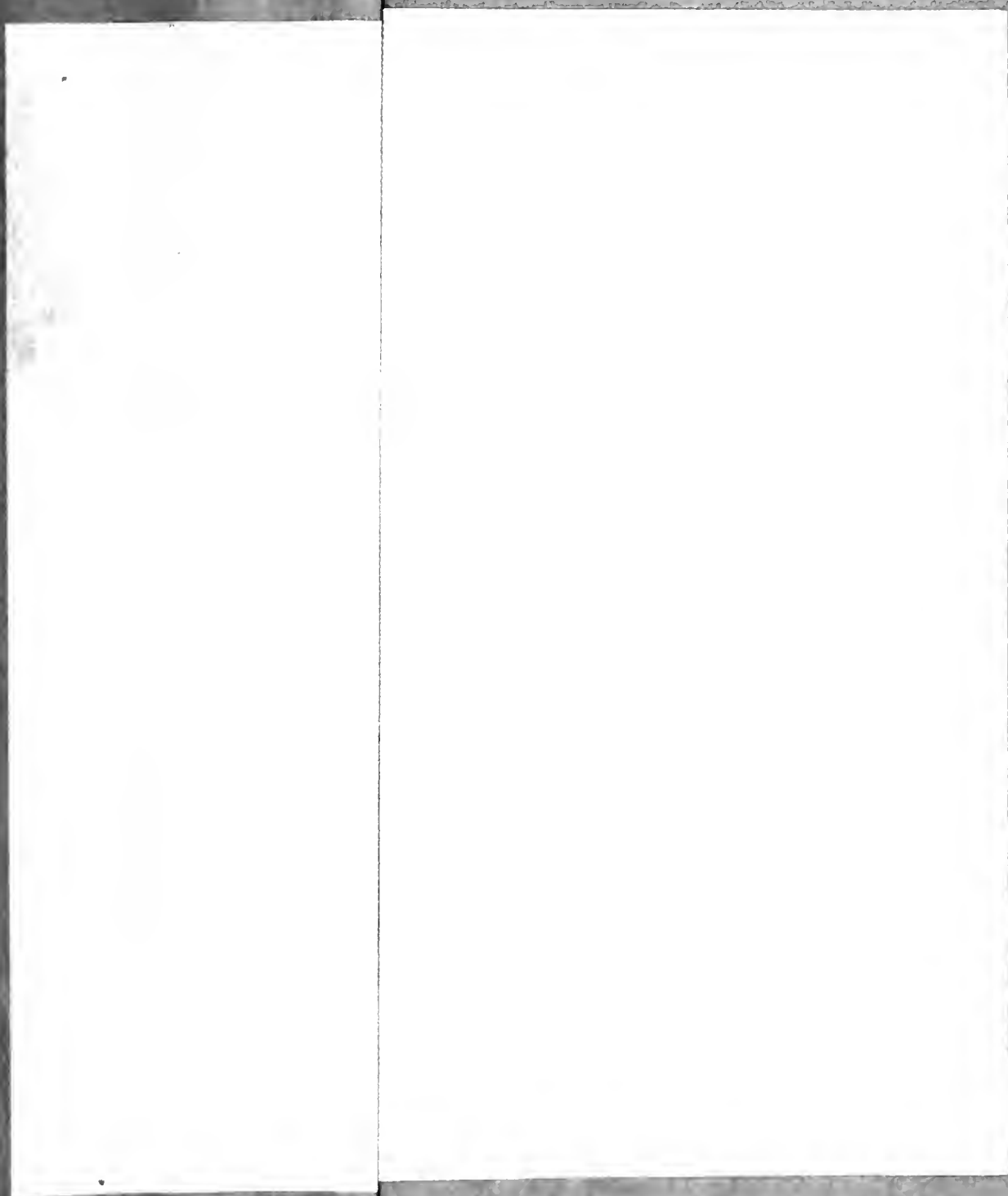
Time	Lat	Long	Alt	Wind	Temp	Pressure
0000	10.0	100.0	1000	10.0	10.0	10.0
0005	10.1	100.1	1001	10.1	10.1	10.1
0010	10.2	100.2	1002	10.2	10.2	10.2
0015	10.3	100.3	1003	10.3	10.3	10.3
0020	10.4	100.4	1004	10.4	10.4	10.4
0025	10.5	100.5	1005	10.5	10.5	10.5
0030	10.6	100.6	1006	10.6	10.6	10.6
0035	10.7	100.7	1007	10.7	10.7	10.7
0040	10.8	100.8	1008	10.8	10.8	10.8
0045	10.9	100.9	1009	10.9	10.9	10.9
0050	11.0	101.0	1010	11.0	11.0	11.0
0055	11.1	101.1	1011	11.1	11.1	11.1
0100	11.2	101.2	1012	11.2	11.2	11.2
0105	11.3	101.3	1013	11.3	11.3	11.3
0110	11.4	101.4	1014	11.4	11.4	11.4
0115	11.5	101.5	1015	11.5	11.5	11.5
0120	11.6	101.6	1016	11.6	11.6	11.6
0125	11.7	101.7	1017	11.7	11.7	11.7
0130	11.8	101.8	1018	11.8	11.8	11.8
0135	11.9	101.9	1019	11.9	11.9	11.9
0140	12.0	102.0	1020	12.0	12.0	12.0
0145	12.1	102.1	1021	12.1	12.1	12.1
0150	12.2	102.2	1022	12.2	12.2	12.2
0155	12.3	102.3	1023	12.3	12.3	12.3
0200	12.4	102.4	1024	12.4	12.4	12.4
0205	12.5	102.5	1025	12.5	12.5	12.5
0210	12.6	102.6	1026	12.6	12.6	12.6
0215	12.7	102.7	1027	12.7	12.7	12.7
0220	12.8	102.8	1028	12.8	12.8	12.8
0225	12.9	102.9	1029	12.9	12.9	12.9
0230	13.0	103.0	1030	13.0	13.0	13.0
0235	13.1	103.1	1031	13.1	13.1	13.1
0240	13.2	103.2	1032	13.2	13.2	13.2
0245	13.3	103.3	1033	13.3	13.3	13.3
0250	13.4	103.4	1034	13.4	13.4	13.4
0255	13.5	103.5	1035	13.5	13.5	13.5
0300	13.6	103.6	1036	13.6	13.6	13.6
0305	13.7	103.7	1037	13.7	13.7	13.7
0310	13.8	103.8	1038	13.8	13.8	13.8
0315	13.9	103.9	1039	13.9	13.9	13.9
0320	14.0	104.0	1040	14.0	14.0	14.0
0325	14.1	104.1	1041	14.1	14.1	14.1
0330	14.2	104.2	1042	14.2	14.2	14.2
0335	14.3	104.3	1043	14.3	14.3	14.3
0340	14.4	104.4	1044	14.4	14.4	14.4
0345	14.5	104.5	1045	14.5	14.5	14.5
0350	14.6	104.6	1046	14.6	14.6	14.6
0355	14.7	104.7	1047	14.7	14.7	14.7
0400	14.8	104.8	1048	14.8	14.8	14.8
0405	14.9	104.9	1049	14.9	14.9	14.9
0410	15.0	105.0	1050	15.0	15.0	15.0
0415	15.1	105.1	1051			

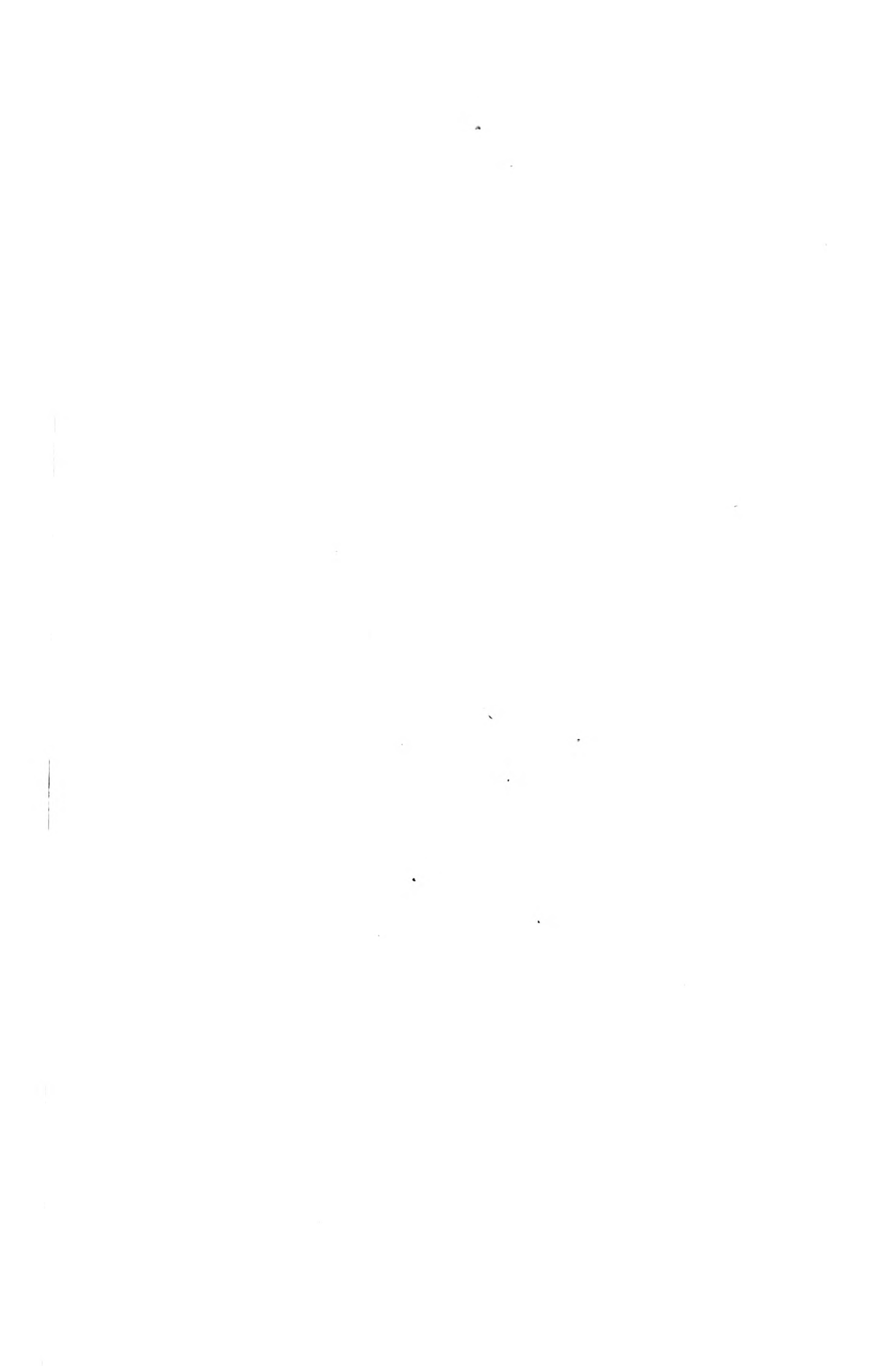
1. The first part of the document is a list of names and addresses, which are arranged in a columnar format. The names are written in a cursive script, and the addresses are written in a more formal, printed style. The list is organized into two columns, with the names on the left and the addresses on the right.

2. The second part of the document is a list of names and addresses, which are arranged in a columnar format. The names are written in a cursive script, and the addresses are written in a more formal, printed style. The list is organized into two columns, with the names on the left and the addresses on the right.

3. The third part of the document is a list of names and addresses, which are arranged in a columnar format. The names are written in a cursive script, and the addresses are written in a more formal, printed style. The list is organized into two columns, with the names on the left and the addresses on the right.













PART II.

Test # 2.

DISCHARGING AT AN INTERMITTANT RATE.

1777

1778

1779

Test # 2.

Cell # 2.

In this test the cell was prepared the same as in Test #1 using a solution having the same density. The cell was automatically discharged for a period of 10.5 seconds once during each two minutes through a resistance giving an average value of current of 2.88 amperes.

The quantities on the data sheets for this test have the same meaning as in Test # 1.

#### Calculations and Results.

Weight of Zn + Hg before test = 6.0586 lbs.

Weight of Zn + Hg after test = 5.642 lbs.

Weight of Zn consumed = .4166 lbs. = 188 gms.

In 560 hours there were  $560 \times 30$  or 16800 contacts of 10.5 seconds each at 2.88 amperes or equivalent to  $49 \times 2.88 = 141.2 \times 3600 \times .000336 = 171.1$  gms.

Curves were plotted showing the variation of amperes volts and temperature of the cell with time in hours. The curves being determined by plotting from point to point. The areas of the ampere-time curve, and volt-time curve were determined accurately by the use of a planimeter, and the average value of the current and voltage were determined therefrom.

The zinc consumed by local action in this cell

Test # 2.

Cell # 2.

In this test the cell was prepared the same as in

Test #1 using a solution having the same formula.

The cell was automatically discharged for a period of

10.5 seconds once during each two minutes through a

resistance giving an average value of current of 2.88

amperes.

The quantities on the data sheets for this test

have the same meaning as in Test # 1.

Calculations and results.

Weight of Zn before test = 2.0886 lbs.

Weight of Zn after test = 2.642 lbs.

Weight of Zn consumed = .4166 lbs. = 188 mgs.

In 560 hours there were 240 x 30 or 16800 contacts

of 10.5 seconds each at 2.88 amperes or equivalent to

$49 \times 2.88 = 141.2 \times 8000 = 1129600 = 112.96 \text{ amp-hrs.}$

Curves were plotted showing the variation of amperes

and temperature of the cell with time in hours.

The curves being determined by plotting first point to

point. The areas of the amperes-time curves, and volt-

age curves were determined respectively by the use of a

planimeter, and the average value of the current and

voltage were determined from them.

The zinc consumed by local action in this cell

was 16.9 gms., therefore the efficiency was 91.25%

#### Cost of Materials.

Weight of outer solution = 7.237 lbs.

Weight of inner solution = 3.106 lbs.

Total weight of solution = 10.443 lbs.

Since the density of acid = 15° Baum, or 1.116 lbs sp. gr., a cu. ft. of this liquid weighs 69.6032 lbs, and contains 15.904% acid, the weight of acid in liquid is 1.67 lbs.

$H_2SO_4$  consumed = 1.509 x .4166 lbs. = .629 lbs. 100% acid or .655 lbs. commercial acid, which would cost .987 cents. The  $KClO_3$  consumed equals .416 x .655 = .272 lbs., or zinc consumed would cost 3.549 cents.

The total cost of materials consumed allowing 80% chemical efficiency for  $H_2SO_4$  and  $KClO_3$ , in producing 186 watts is 7.689 cents or 43.1 cents per K.W. hour.

was 16.9 lbs., therefore it was 11.25%

Cost of Materials.

Weight of outer solution = 7.837 lbs.

Weight of inner solution = 8.106 lbs.

Total weight of solution = 15.943 lbs.

Since the density of acid = 1.85 g./cc., or 1.16 lbs.

sp. gr., a cu. ft. of this liquid weighs 69.607 lbs.

and contains 15.904% acid, the weight of acid in

liquid is 1.67 lbs.

$H_2SO_4$  consumed =  $1.67 \times 1.16$  lbs. = .623 lbs.

100% acid or .623 lbs. commercial acid, which would

cost .287 cents. The 4.10% consumed equals  $.410 \times$

.623 = .258 lbs., or this consumed would cost

8.743 cents.

The total cost of materials consumed is 10.410

operational efficiency for  $H_2SO_4$  and  $H_2O$ , in producing

1 lb. water is 7.680 cents or 48.1 cents per lb. of water.



C E L L NO. II.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 AM		.16		15.		
12:30 PM		1.821		16.5		
10	1.46	1.761	2.81	17.	.106	8
6 AM	1.44	1.76	2.85	17.	.109	16
2 PM	1.506	1.81	2.81	17.	.109	24
10 PM	1.46	1.76	2.9	17.	.105	32
6 AM	1.426	1.761	3.11	17.	.107	40
	14.5 oz. H <sub>2</sub> O added					
2 PM	1.377	1.717	3.11	15.	.1094	48
10	1.387	1.717	3.1	16.1	.105	56
6 AM	1.38	1.711	3.06	16.2	.107	64
2 PM	1.356	1.678	3.05	16.8	.1058	72
10	1.36	1.666	3.06	16.5	.100	80
6 AM	1.33	1.64	3.09	16.8	.100	88
2 PM	1.338	1.638	2.99	17.	.1008	96
10	1.336	1.64	2.995	17.5	.103	104
6 AM	1.35	1.674	3.01	17.5	.1075	112
2 PM	1.34	1.65	3.02	17.4	.102	120



C E L L NO. II.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
10 PM	1.34	1.65	3.02	18.5	.102	128
6 AM	1.336	1.646	2.93	18.2	.102	136
	3 oz. H <sub>2</sub> O added					
2 PM	1.326	1.66	2.89	17.5	.1176	144
10	1.317	1.636	2.89	16.5	.109	152
6 AM	1.318	1.618	2.98	17.2	.1006	160
2 PM	1.33	1.636	2.99	17.5	.104	168
10	1.336	1.606	2.86	17.5	.107	176
6 AM	1.33	1.616	2.83	18.	.1008	184
2 PM	1.34	1.62	2.875	17.8	.1004	192
10	1.336	1.616	2.83	18.1	.099	200
6 AM	1.332	1.62	2.87	18.6	.1001	208
	6 oz. H <sub>2</sub> O added					
2 PM	1.336	1.617	2.9	18.1	.0973	216
10	1.358	1.638	2.81	18.6	.0998	224
6 AM	1.346	1.617	2.82	18.8	.0995	232
2 PM	1.336	1.628	2.89	19.3	.0975	240

# Table 1

Date		Time	Lat	Long	Alt	Remarks
1954	10	08:00	30.8	106.1	1000	Clear
11	08:00	30.8	106.1	1000	1000	Clear
12	08:00	30.8	106.1	1000	1000	Clear
13	08:00	30.8	106.1	1000	1000	Clear
14	08:00	30.8	106.1	1000	1000	Clear
15	08:00	30.8	106.1	1000	1000	Clear
16	08:00	30.8	106.1	1000	1000	Clear
17	08:00	30.8	106.1	1000	1000	Clear
18	08:00	30.8	106.1	1000	1000	Clear
19	08:00	30.8	106.1	1000	1000	Clear
20	08:00	30.8	106.1	1000	1000	Clear
21	08:00	30.8	106.1	1000	1000	Clear
22	08:00	30.8	106.1	1000	1000	Clear
23	08:00	30.8	106.1	1000	1000	Clear
24	08:00	30.8	106.1	1000	1000	Clear
25	08:00	30.8	106.1	1000	1000	Clear
26	08:00	30.8	106.1	1000	1000	Clear
27	08:00	30.8	106.1	1000	1000	Clear
28	08:00	30.8	106.1	1000	1000	Clear
29	08:00	30.8	106.1	1000	1000	Clear
30	08:00	30.8	106.1	1000	1000	Clear

# C E L L NO. II.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
10 PM	1.336	1.616	2.91	20.	.0963	248
6 AM	1.296	1.606	2.86	20.	.1085	256
2 PM	1.306	1.611	3.01	21.	.1012	264
10	1.296	1.586	2.91	21.3	.0998	272
6 AM	1.296	1.616	2.81	21.8	.114	280
2 PM	1.316	1.621	2.96	21.9	.1028	288
10 PM	1.311	1.616	2.89	22.	.1055	296
6 AM	1.316	1.62	2.89	22.8	.105	304
2 PM	1.316	1.616	2.94	22.8	.1021	312
10 PM	1.296	1.586	2.89	23.	<del>.1008</del>	320
6 AM	1.3	1.596	2.89	23.5	.1002	328
2 PM	1.296	1.596	2.86	23.	.105	336
	6 oz. H <sub>2</sub> O added					
10	1.3	1.39	2.87	23.	.101	344
6 AM	1.268	1.55	2.8	23.5	.101	352
2 PM	1.30	1.596	2.84	24.	.104	360
10	1.32	1.596	2.84	24.	.097	368
6 AM	1.3	1.586	2.83	25.	.1011	376

Q E L I NO. 11.

Time	A	B	I	Debit	T	Rate
10 PM	1.388	1.618	8.91	80.	8000.	848
9 AM	1.388	1.608	8.88	80.	1087.	888
8 PM	1.308	1.611	8.01	81.	1.18	804
10	1.308	1.588	8.91	81.8	8888.	841
9 AM	1.388	1.618	8.91	81.8	114	880
8 PM	1.618	1.621	8.88	81.9	1084	888
10 PM	1.611	1.618	8.88	82.	1088	888
9 AM	1.618	1.68	8.88	82.8	109	804
8 PM	1.618	1.618	8.84	82.8	1081	818
10 PM	1.388	1.588	8.88	88.	1008	880
9 AM	1.3	1.588	8.88	81.8	1008	888
8 PM	1.588	1.588	8.88	88.	108	888
	8.88	8.88				
10	1.3	1.38	8.84	88.	101	844
9 AM	1.388	1.58	8.8	88.8	101	888
8 PM	1.80	1.588	8.84	84.	104	800
10	1.38	1.588	8.84	84.	104	848
9 AM	1.3	1.588	8.84	88.	104	848

C E L L NO. II.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 PM	1.28	1.576	2.81	25.	.102	384
10	1.26	1.578	2.56	25.	.118	392
6 AM	1.242	1.576	2.76	25.	.121	400
2 PM	1.262	1.576	2.73	25.1	.1151	408
10	1.25	1.564	2.83	25.5	.111	416
6 AM	1.22	1.558	2.93	26.	.1161	424
2 PM	1.22	1.556	2.89	25.5	.113	432
10	1.24	1.559	2.89	26.	.1102	440
6 AM	1.23	1.566	3.01	26.3	.113	448
2 PM	1.24	1.566	2.74	26.3	.119	456
10 PM	1.25	1.576	2.81	26.4	.116	464
6 AM	1.24	1.566	2.86	27.5	.114	472
2 PM	1.26	1.571	2.8	26.5	.113	480
,	6 oz. H <sub>2</sub> O added					
10 PM	1.24	1.566	2.7	25.5	.1208	488
6 AM	1.23	1.576	2.71	26.5	.1276	496
2 PM	1.23	1.576	2.81	26.2	.1241	504

# U.S. DEPARTMENT OF AGRICULTURE

Year	Month	Day	Time	Lat.	Long.	Alt.
1911	Aug.	10	8 PM	1.38	1.378	2.81
1911	Aug.	10	10	1.38	1.378	2.88
1911	Aug.	10	8 AM	1.345	1.378	2.78
1911	Aug.	10	8 PM	1.388	1.378	2.78
1911	Aug.	10	10	1.38	1.378	2.88
1911	Aug.	10	8 AM	1.38	1.378	2.78
1911	Aug.	10	8 PM	1.38	1.378	2.88
1911	Aug.	10	10	1.34	1.378	2.78
1911	Aug.	10	8 AM	1.38	1.378	2.78
1911	Aug.	10	8 PM	1.34	1.378	2.78
1911	Aug.	10	10 PM	1.38	1.378	2.81
1911	Aug.	10	8 AM	1.34	1.378	2.88
1911	Aug.	10	8 PM	1.38	1.371	2.78
1911	Aug.	10	10 PM	1.34	1.378	2.78
1911	Aug.	10	8 AM	1.38	1.378	2.78
1911	Aug.	10	8 PM	1.38	1.378	2.81

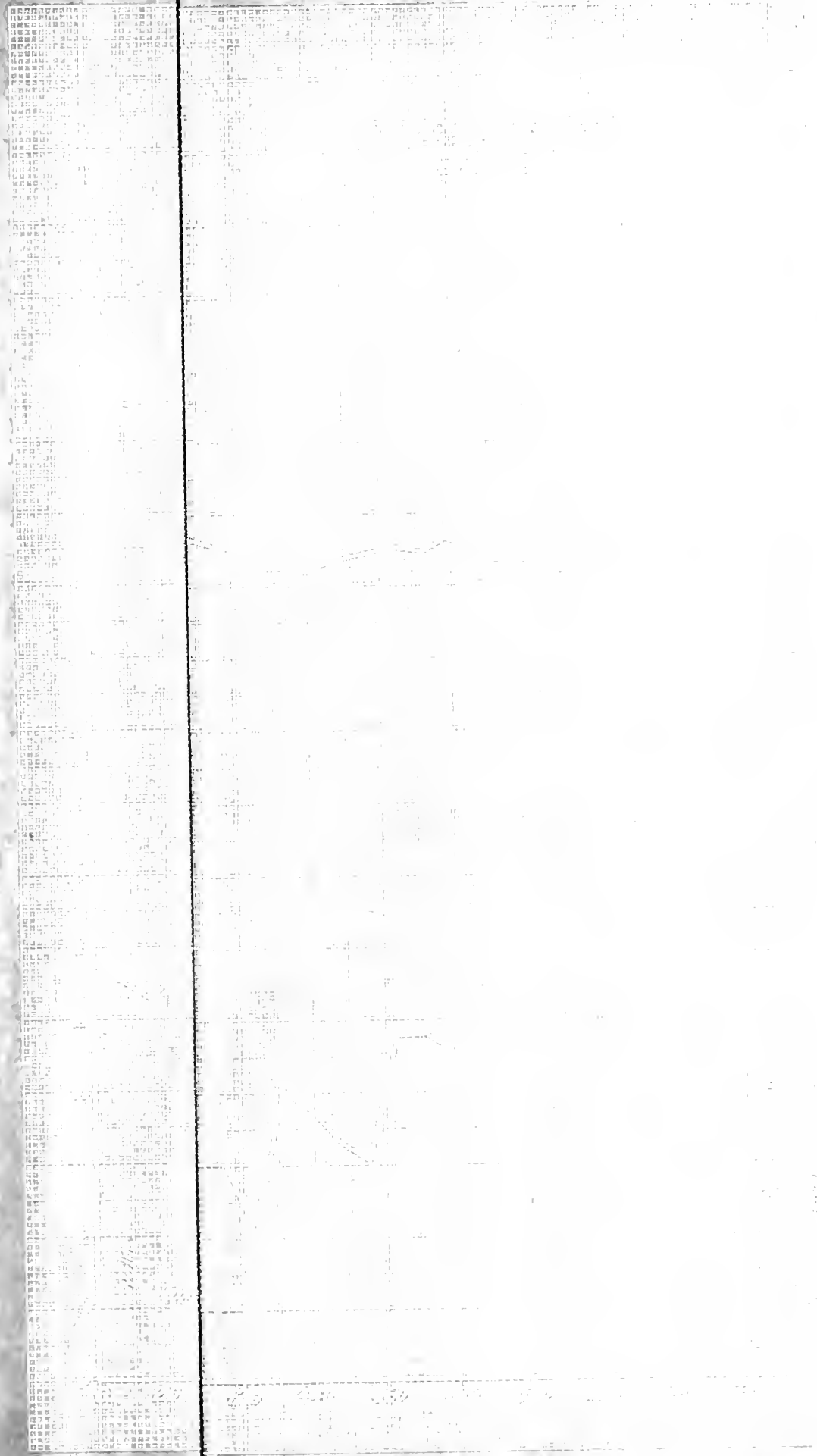


# C E L L NO. II.

Time	E 1	E 2	I	Dens- ty	r	Hrs.
10 PM	1.21	1.556	2.80	26.5	.1278	512
6 AM	1.21	1.546	2.73	27.1	.123	520
2 PM	1.30	1.637	2.80	27.1	.121	528
10 PM	1.21	1.556	2.71	27.1	.1277	536
6 AM	1.24	1.576	2.7	27.4	.1212	544
2 PM	1.2	1.556	2.76	27.4	.128	552
10	1.2	1.536	2.71	28.1	.124	560

C 2 1 1 NO. 11.

Time	W I	S F	I	Trans- v	r	W I
10 PM	1.81	1.258	2.80	2.53	1.178	2.16
8 AM	1.81	1.242	2.73	2.71	1.182	2.17
2 PM	1.30	1.234	2.80	2.71	1.181	2.18
10 PM	1.81	1.258	2.71	2.71	1.187	2.19
8 AM	1.24	1.270	2.7	2.74	1.198	2.20
2 PM	1.2	1.252	2.70	2.74	1.19	2.21
10	1.2	1.232	2.71	2.71	1.184	2.22



Time	W	S	I	Trans- mity	r	W
10 PM	1.81	1.588	2.80	25.8	1.178	018
8 AM	1.81	1.548	2.78	24.1	1.188	280
2 PM	1.80	1.687	2.80	27.1	1.181	008
10 PM	1.81	1.588	2.71	27.1	1.187	218
8 AM	1.84	1.576	2.7	27.4	1.188	244
2 PM	1.8	1.582	2.76	27.4	1.18	218
10	1.8	1.588	2.77	27.1	1.184	200

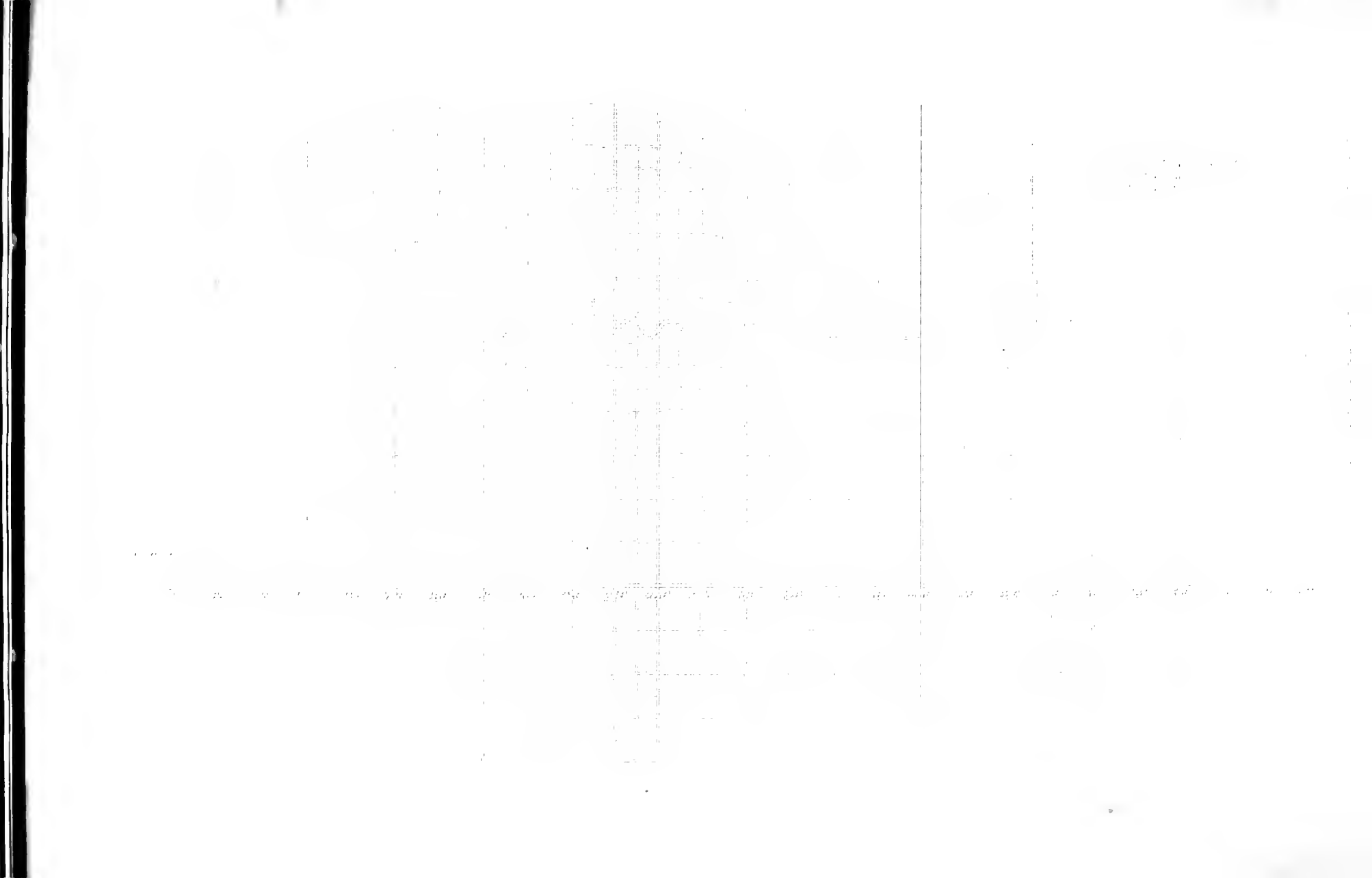














PART III.

Test # 3.

DISCHARGING CELL AT AN INTERMITTANT RATE.

.I I TAA

.E + JET

DISCHARGING WELL AT AN INTERMEDIATE LEVEL

Test # 3.

Cell # 3.

In this test the cell was prepared and operated under practically the same conditions as cell # 2, with the exception that the value of the current was a little lower.

Curves were plotted as in previous tests, showing the variation in the value of amperes, volts and temperature with respect to time in hours. The same care was taken in obtaining the average values, as was previously exercised.

#### Calculations and Results.

Weight of zinc + mercury before test                      6.0625 lbs.

Weight of zinc + mercury after test                      5.663 lbs.

Weight of zinc consumed = .3995 lbs = 181.5 gms.

The number of hours in service was 560, the number of contacts was 16800 and the amp-hrs =  $49 \times 136.5$ .

The theoretical value of the loss of zinc =  $136.5 \times 3600 \times .000336 = 165.1$  gms. The zinc consumed by local action was 16.4 gms., giving an efficiency of 91.25 %.

#### Cost of Materials.

Weight of outer solution                                      6.739 lbs.

Weight of inner solution                                      3.536 lbs.

Total weight of solution                                      10.275 lbs.

Amount of acid in 10.275 lbs. of solution = 1.635 lbs.

$H_2SO_4$  consumed in the cell =  $1.509 \times .3995 = .602$  lbs. of  
100 % acid or .627 lbs. of commercial acid, and would  
(66)

Test 4.3.

Test 4.3.

In this test the cell was prepared and operated under practically the same conditions as cell 4.2, with the exception that the value of the current was a little lower.

Curves were plotted as in previous tests, showing the variation in the value of amperes, voltage and temperature with respect to time in hours. The same care was in obtaining the average values, as was previously explained. Calculations and Results.

Weight of zinc: mercury before test 6.0037 lbs.  
Weight of zinc: mercury after test 6.0037 lbs.  
Volume of zinc consumed = .3898 lbs = 161.2 c.c.  
The number of hours in service was 260, the number of contacts was 16800 and the amp-hrs =  $48 \times 16800 = 806400$ .  
The theoretical value of the loss of zinc =  $16800 \times 8000 \times .000336 = 165.1$  gms. The zinc consumed by local action was 16.4 gms., giving an efficiency of 91.25%.

Cost of materials.

Weight of zinc solution 6.783 lbs.  
Weight of inner solution 3.836 lbs.  
Total weight of solution 10.619 lbs.  
Amount of acid in 1.875 lbs. of solution = 1.077 lbs.  
Acid consumed in the cell =  $1.40 \times .0007 = .00098$  lbs. of acid or .687 lbs. of commercial acid, and would (66)

cost .94 cents.  $\text{KClO}_3$  consumed  $= .418 \times .627 = .262$  lbs.  
and costs 2.57 cents and zn consumed  $= 3.38$  cents.

The total cost of materials consumed allowing 80%  
for chemicals used is 7.76 cts. for 178.2 watt-hrs. or  
43.4 cts. per K.W.Hr.

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C E L L NO. III.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 AM		.16		15.		
<del>12</del> 3 PM		1.82		16.5		
10 PM	1.456	1.746	2.51	16.	.111	8
6 AM	1.456	1.746	2.51	16.2	.111	16
2 PM	1.481	1.78	2.61	16.5	.114	24
10	1.481	1.776	2.6	16.5	.113	32
	14.4 oz. H <sub>2</sub> O added					
6 AM	1.48	1.775	2.77	15.	.108	40
2 PM	1.43	1.741	2.83	16.1	.107	48
10	1.435	1.735	2.85	16.5	.105	56
6 AM	1.431	1.714	2.72	16.55	.104	64
2 PM	1.35	1.676	3.	16.8	.1068	72
10	1.355	1.68	3.1	16.7	.1045	80
6 AM	1.338	1.663	2.9	17.	.105	88
2 PM	1.378	1.664	2.69	17.5	.106	96
10	1.32	1.66	3.3	17.5	.103	104
6 AM	1.325	1.674	3.3	17.5	.104	112
2 PM	1.31	1.65	3.33	17.4	.103	120

# TABLE 1

Year	Area	Population	Area	Population	Area	Population
1950	100	100	100	100	100	100
1951	100	100	100	100	100	100
1952	100	100	100	100	100	100
1953	100	100	100	100	100	100
1954	100	100	100	100	100	100
1955	100	100	100	100	100	100
1956	100	100	100	100	100	100
1957	100	100	100	100	100	100
1958	100	100	100	100	100	100
1959	100	100	100	100	100	100
1960	100	100	100	100	100	100
1961	100	100	100	100	100	100
1962	100	100	100	100	100	100
1963	100	100	100	100	100	100
1964	100	100	100	100	100	100
1965	100	100	100	100	100	100
1966	100	100	100	100	100	100
1967	100	100	100	100	100	100
1968	100	100	100	100	100	100
1969	100	100	100	100	100	100
1970	100	100	100	100	100	100
1971	100	100	100	100	100	100
1972	100	100	100	100	100	100
1973	100	100	100	100	100	100
1974	100	100	100	100	100	100
1975	100	100	100	100	100	100
1976	100	100	100	100	100	100
1977	100	100	100	100	100	100
1978	100	100	100	100	100	100
1979	100	100	100	100	100	100
1980	100	100	100	100	100	100
1981	100	100	100	100	100	100
1982	100	100	100	100	100	100
1983	100	100	100	100	100	100
1984	100	100	100	100	100	100
1985	100	100	100	100	100	100
1986	100	100	100	100	100	100
1987	100	100	100	100	100	100
1988	100	100	100	100	100	100
1989	100	100	100	100	100	100
1990	100	100	100	100	100	100
1991	100	100	100	100	100	100
1992	100	100	100	100	100	100
1993	100	100	100	100	100	100
1994	100	100	100	100	100	100
1995	100	100	100	100	100	100
1996	100	100	100	100	100	100
1997	100	100	100	100	100	100
1998	100	100	100	100	100	100
1999	100	100	100	100	100	100
2000	100	100	100	100	100	100

C E L L NO. III.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
10 PM	1.31	1.65	3.33	18.5	.103	128
	3 oz. H <sub>2</sub> O added					
6 AM	1.33	1.66	3.1	17.5	.1062	136
2 PM	1.46	1.76	2.83	16.	.1058	144
10	1.34	1.65	2.9	16.6	.107	152
6 AM	1.361	1.651	2.83	17.	.1050	160
2 PM	1.3	1.594	2.89		.1019	168
10	1.32	1.636	2.93		.1072	176
6 AM	1.34	1.631	2.91		.1	184
2 PM	1.3	1.611	2.72		.1182	192
10	1.33	1.646	2.52		.1162	200
6 AM	1.36	1.66	2.71		.1108	208
	6 oz. H <sub>2</sub> O added					
2 PM	1.32	1.616	2.74		.1081	216
10	1.345	1.656	2.66	19.	.117	224
6 AM	1.33	1.634	2.66	19.	.1142	232
2 PM	1.315	1.646	2.82	19.5	.1174	240

[illegible]

Year	Month	Temperature (°C)	Humidity (%)	Wind Speed (km/h)	Cloud Cover (%)	Notes
1950	Jan	12.5	65	15.0	40	Clear
1951	Feb	13.0	68	16.0	35	Light Rain
1952	Mar	14.0	70	17.0	30	Clear
1953	Apr	15.0	72	18.0	25	Clear
1954	May	16.0	75	19.0	20	Clear
1955	Jun	17.0	78	20.0	15	Clear
1956	Jul	18.0	80	21.0	10	Clear
1957	Aug	19.0	82	22.0	5	Clear
1958	Sep	20.0	85	23.0	5	Clear
1959	Oct	21.0	88	24.0	5	Clear
1960	Nov	22.0	90	25.0	5	Clear
1961	Dec	23.0	92	26.0	5	Clear

C E L L NO. III.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
10 PM	1.318	1.614	2.81	19.9	.1055	248
6 AM	1.32	1.626	2.81	20.0	.1088	256
2 PM	1.32	1.636	2.73	21.	.1158	264
10 PM	1.31	1.626	2.66	21.	.1188	272
6 AM	1.31	1.616	2.68	21.4	.1143	280
2 PM	1.32	1.646	2.73	21.8	.1197	288
10	1.32	1.616	2.91	22.	.1018	296
6 AM	1.21	1.506	2.66	22.5	.1112	304
2 PM	1.26	1.586	2.74	22.7	.119	312
10	1.265	1.60	2.86	23.	.117	320
6 AM	1.26	1.591	2.79	23.2	.1185	328
2 PM	1.3	1.616	2.89		.1094	336
	6 oz. H <sub>2</sub> O added					
10	1.3	1.606	2.99	23.2	.1023	344
6 AM	1.3	1.614	2.81	23.2	.1118	352
2 PM	1.3	1.596	2.75	23.2	.1078	360
10	1.255	1.596	2.86	23.5	.1192	368

TABLE NO. 111

Time	Lat	Long	Alt	Temp	Wind	Clouds
10 01	33.5	108.1	10.0	58.2	1.014	1.018
10 02	33.5	108.1	10.0	58.2	1.014	1.018
10 03	33.5	108.1	10.0	58.2	1.014	1.018
10 04	33.5	108.1	10.0	58.2	1.014	1.018
10 05	33.5	108.1	10.0	58.2	1.014	1.018
10 06	33.5	108.1	10.0	58.2	1.014	1.018
10 07	33.5	108.1	10.0	58.2	1.014	1.018
10 08	33.5	108.1	10.0	58.2	1.014	1.018
10 09	33.5	108.1	10.0	58.2	1.014	1.018
10 10	33.5	108.1	10.0	58.2	1.014	1.018
10 11	33.5	108.1	10.0	58.2	1.014	1.018
10 12	33.5	108.1	10.0	58.2	1.014	1.018
10 13	33.5	108.1	10.0	58.2	1.014	1.018
10 14	33.5	108.1	10.0	58.2	1.014	1.018
10 15	33.5	108.1	10.0	58.2	1.014	1.018
10 16	33.5	108.1	10.0	58.2	1.014	1.018
10 17	33.5	108.1	10.0	58.2	1.014	1.018
10 18	33.5	108.1	10.0	58.2	1.014	1.018
10 19	33.5	108.1	10.0	58.2	1.014	1.018
10 20	33.5	108.1	10.0	58.2	1.014	1.018
10 21	33.5	108.1	10.0	58.2	1.014	1.018
10 22	33.5	108.1	10.0	58.2	1.014	1.018
10 23	33.5	108.1	10.0	58.2	1.014	1.018
10 24	33.5	108.1	10.0	58.2	1.014	1.018
10 25	33.5	108.1	10.0	58.2	1.014	1.018
10 26	33.5	108.1	10.0	58.2	1.014	1.018
10 27	33.5	108.1	10.0	58.2	1.014	1.018
10 28	33.5	108.1	10.0	58.2	1.014	1.018
10 29	33.5	108.1	10.0	58.2	1.014	1.018
10 30	33.5	108.1	10.0	58.2	1.014	1.018

C E L L NO. III.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
6 AM	1.24	1.58	2.86	23.6	.1188	376
2 PM	1.24	1.56	2.77	24.5	.1175	384
10	1.242	1.576	2.83	24.2	.118	392
6 AM	1.236	1.57	2.81	25.	.119	400
2 PM	1.236	1.57	2.81	25.1	.1188	408
10	1.24	1.576	2.82	25.8	.119	416
6 AM	1.25	1.566	2.65	25.9	.1192	424
2 PM	1.235	1.57	2.83	26.	.1182	432
10	1.23	1.56	2.82	26.3	.119	440
6 AM	1.22	1.571	2.72	26.6	.129	448
2 PM	1.25	1.574	2.51	26.8	.129	456
10	1.24	1.574	2.66	26.6	.1255	464
6 AM	1.24	1.574	2.69	27.3	.129	472
2 PM	1.22	1.576	2.76	27.5	.129	480
	6 oz. H <sub>2</sub> O added.					
10	1.222	1.576	2.71	26.2	.1307	488
6 AM	1.23	1.566	2.56	26.8	.1312	496

# Table I

Code	Year	Age	Sex	Height	Weight	Notes
1	1950	20	M	170	65	3
2	1951	21	M	175	70	4
3	1952	22	M	180	75	5
4	1953	23	M	185	80	6
5	1954	24	M	190	85	7
6	1955	25	M	195	90	8
7	1956	26	M	200	95	9
8	1957	27	M	205	100	10
9	1958	28	M	210	105	11
10	1959	29	M	215	110	12
11	1960	30	M	220	115	13
12	1961	31	M	225	120	14
13	1962	32	M	230	125	15
14	1963	33	M	235	130	16
15	1964	34	M	240	135	17
16	1965	35	M	245	140	18
17	1966	36	M	250	145	19
18	1967	37	M	255	150	20
19	1968	38	M	260	155	21
20	1969	39	M	265	160	22
21	1970	40	M	270	165	23
22	1971	41	M	275	170	24
23	1972	42	M	280	175	25
24	1973	43	M	285	180	26
25	1974	44	M	290	185	27
26	1975	45	M	295	190	28
27	1976	46	M	300	195	29
28	1977	47	M	305	200	30
29	1978	48	M	310	205	31
30	1979	49	M	315	210	32
31	1980	50	M	320	215	33
32	1981	51	M	325	220	34
33	1982	52	M	330	225	35
34	1983	53	M	335	230	36
35	1984	54	M	340	235	37
36	1985	55	M	345	240	38
37	1986	56	M	350	245	39
38	1987	57	M	355	250	40
39	1988	58	M	360	255	41
40	1989	59	M	365	260	42
41	1990	60	M	370	265	43
42	1991	61	M	375	270	44
43	1992	62	M	380	275	45
44	1993	63	M	385	280	46
45	1994	64	M	390	285	47
46	1995	65	M	395	290	48
47	1996	66	M	400	295	49
48	1997	67	M	405	300	50
49	1998	68	M	410	305	51
50	1999	69	M	415	310	52
51	2000	70	M	420	315	53
52	2001	71	M	425	320	54
53	2002	72	M	430	325	55
54	2003	73	M	435	330	56
55	2004	74	M	440	335	57
56	2005	75	M	445	340	58
57	2006	76	M	450	345	59
58	2007	77	M	455	350	60
59	2008	78	M	460	355	61
60	2009	79	M	465	360	62
61	2010	80	M	470	365	63
62	2011	81	M	475	370	64
63	2012	82	M	480	375	65
64	2013	83	M	485	380	66
65	2014	84	M	490	385	67
66	2015	85	M	495	390	68
67	2016	86	M	500	395	69
68	2017	87	M	505	400	70
69	2018	88	M	510	405	71
70	2019	89	M	515	410	72
71	2020	90	M	520	415	73
72	2021	91	M	525	420	74
73	2022	92	M	530	425	75
74	2023	93	M	535	430	76
75	2024	94	M	540	435	77
76	2025	95	M	545	440	78
77	2026	96	M	550	445	79
78	2027	97	M	555	450	80
79	2028	98	M	560	455	81
80	2029	99	M	565	460	82
81	2030	100	M	570	465	83
82	2031	101	M	575	470	84
83	2032	102	M	580	475	85
84	2033	103	M	585	480	86
85	2034	104	M	590	485	87
86	2035	105	M	595	490	88
87	2036	106	M	600	495	89
88	2037	107	M	605	500	90
89	2038	108	M	610	505	91
90	2039	109	M	615	510	92
91	2040	110	M	620	515	93
92	2041	111	M	625	520	94
93	2042	112	M	630	525	95
94	2043	113	M	635	530	96
95	2044	114	M	640	535	97
96	2045	115	M	645	540	98
97	2046	116	M	650	545	99
98	2047	117	M	655	550	100
99	2048	118	M	660	555	101
100	2049	119	M	665	560	102
101	2050	120	M	670	565	103
102	2051	121	M	675	570	104
103	2052	122	M	680	575	105
104	2053	123	M	685	580	106
105	2054	124	M	690	585	107
106	2055	125	M	695	590	108
107	2056	126	M	700	595	109
108	2057	127	M	705	600	110
109	2058	128	M	710	605	111
110	2059	129	M	715	610	112
111	2060	130	M	720	615	113
112	2061	131	M	725	620	114
113	2062	132	M	730	625	115
114	2063	133	M	735	630	116
115	2064	134	M	740	635	117
116	2065	135	M	745	640	118
117	2066	136	M	750	645	119
118	2067	137	M	755	650	120
119	2068	138	M	760	655	121
120	2069	139	M	765	660	122
121	2070	140	M	770	665	123
122	2071	141	M	775	670	124
123	2072	142	M	780	675	125
124	2073	143	M	785	680	126
125	2074	144	M	790	685	127
126	2075	145	M	795	690	128
127	2076	146	M	800	695	129
128	2077	147	M	805	700	130
129	2078	148	M	810	705	131
130	2079	149	M	815	710	132
131	2080	150	M	820	715	133
132	2081	151	M	825	720	134
133	2082	152	M	830	725	135
134	2083	153	M	835	730	136
135	2084	154	M	840	735	137
136	2085	155	M	845	740	138
137	2086	156	M	850	745	139
138	2087	157	M	855	750	140
139	2088	158	M	860	755	141
140	2089	159	M	865	760	142
141	2090	160	M	870	765	143
142	2091	161	M	875	770	144
143	2092	162	M	880	775	145
144	2093	163	M	885	780	146
145	2094	164	M	890	785	147
146	2095	165	M	895	790	148
147	2096	166	M	900	795	149
148	2097	167	M	905	800	150
149	2098	168	M	910	805	151
150	2099	169	M	915	810	152
151	2100	170	M	920	815	153
152	2101	171	M	925	820	154
153	2102	172	M	930	825	155
154	2103	173	M	935	830	156
155	2104	174	M	940	835	157
156	2105	175	M	945	840	158
157	2106	176	M	950	845	159
158	2107	177	M	955	850	160
159	2108	178	M	960	855	161
160	2109	179	M	965	860	162
161	2110	180	M	970	865	163
162	2111	181	M	975	870	164
163	2112	182	M	980	875	165
164	2113	183	M	985	880	166
165	2114	184	M	990	885	167
166	2115	185	M	995	890	168
167	2116	186	M	1000	895	169
168	2117	187	M	1005	900	170
169	2118	188	M	1010	905	171
170	2119	189	M	1015	910	172
171	2120	190	M	1020	915	173
172	2121	191	M	1025	920	174
173	2122	192	M	1030	925	175
174	2123	193	M	1035	930	176
175	2124	194	M	1040	935	177
176	2125	195	M	1045	940	178
177	2126	196	M	1050	945	179
178	2127	197	M	1055	950	180
179	2128	198	M	1060	955	181
180	2129	199	M	1065	960	182
181	2130	200	M	1070	965	183
182	2131	201	M	1075	970	184
183	2132	202	M	1080	975	185
184	2133	203	M	1085	980	186
185	2134	204	M	1090	985	187
186	2135	205	M	1095	990	188
187	2136	206	M	1100	995	189
188	2137	207	M	1105	1000	190
189	2138	208	M	1110	1005	191
190	2139	209	M	1115	1010	192
191	2140	210	M	1120	1015	193
192	2141	211	M	1125	1020	194
193	2142	212	M	1130	1025	195
194	2143	213	M	1135	1030	196
195	2144	214	M	1140	1035	197
196	2145	215	M	1145	1040	198
197	2146	216	M	1150	1045	199
198	2147	217	M	1155	1050	200
199	2148	218	M	1160	1055	201
200	2149	219	M	1165	1060	202
201	2150	220	M	1170	1065	203
202	2151	221	M	1175	1070	204
203	2152	222	M	1180	1075	205
204	2153	223	M	1185	1080	206
205	2154	224	M	1190	1085	207
206	2155	225	M	1195	1090	208
207	2156	226	M	1200	1095	209
208	2157	227	M	1205	1100	210
209						



C E L L NO. III.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 PM	1.22	1.556	2.54	26.8	.1345	504
10	1.26	1.556	2.53	27.5	.133	512
6 AM	1.21	1.556	2.51	28.	.138	520
2 PM	1.28	1.646	2.73	28.4	.1376	528
10	1.24	1.606	2.51	27.4	.138	536
6 AM	1.23	1.584	2.56	28.	.1382	544
2 PM	1.26	1.57	2.41	28.	.1289	552
10	1.24	1.534	2.11	28.8	.139	560

# 0 1 2 3 4 5 6 7 8 9

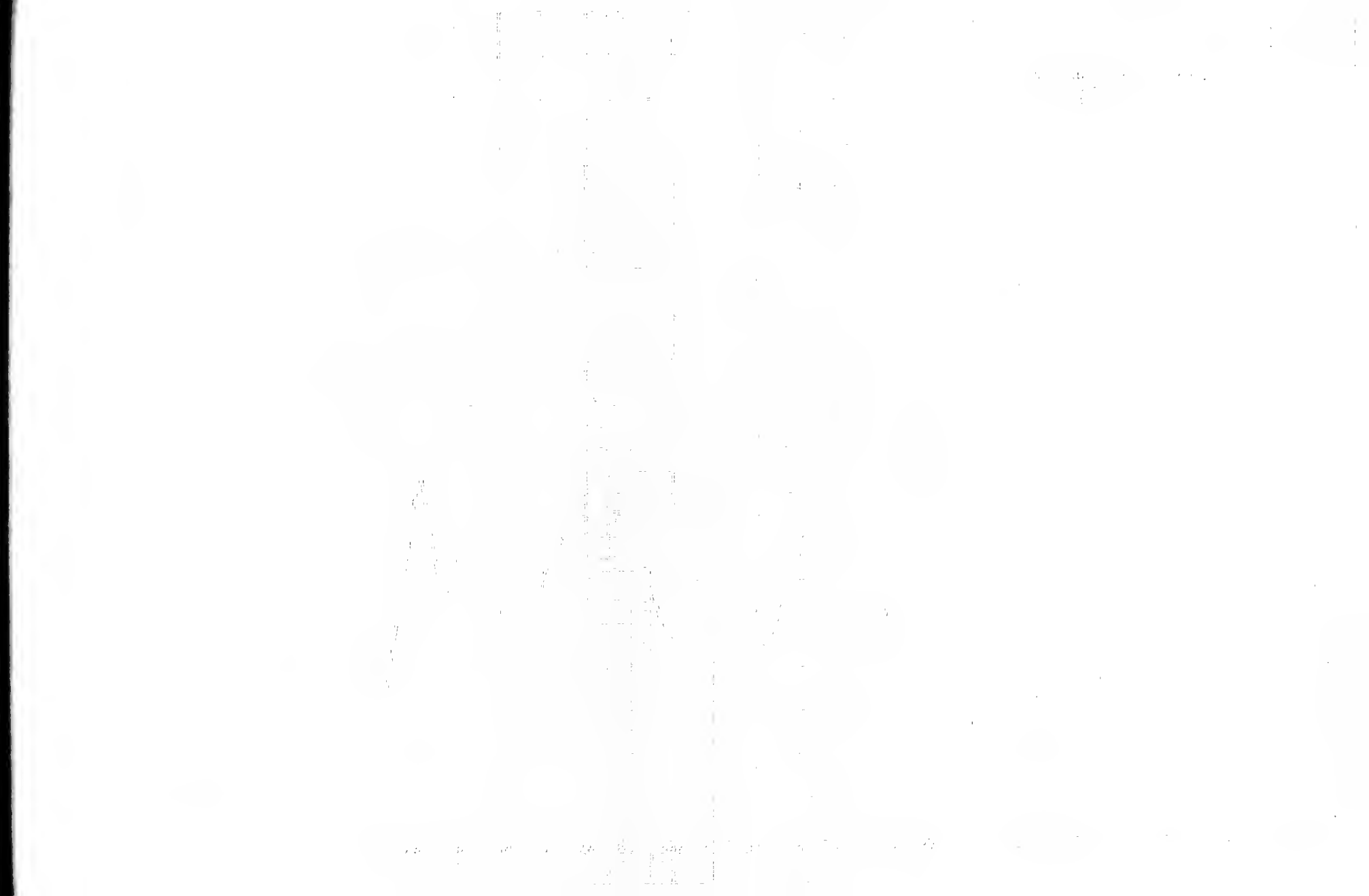
Time	1	2	3	4	5	6
3 PM	1.14	1.14	1.14	1.14	1.14	1.14
10	1.14	1.14	1.14	1.14	1.14	1.14
8 PM	1.14	1.14	1.14	1.14	1.14	1.14
3 PM	1.14	1.14	1.14	1.14	1.14	1.14
10	1.14	1.14	1.14	1.14	1.14	1.14
6 PM	1.14	1.14	1.14	1.14	1.14	1.14
3 PM	1.14	1.14	1.14	1.14	1.14	1.14
10	1.14	1.14	1.14	1.14	1.14	1.14

1. 姓名: 张三  
2. 性别: 男  
3. 年龄: 25  
4. 职业: 教师  
5. 籍贯: 广东  
6. 民族: 汉族  
7. 婚姻状况: 已婚  
8. 子女情况: 一子一女  
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16. 邮编: 100000  
17. 血型: O型  
18. 身高: 175cm  
19. 体重: 70kg  
20. 视力: 正常  
21. 听力: 正常  
22. 语言能力: 普通话、粤语  
23. 兴趣爱好: 阅读、运动、旅游  
24. 特长: 写作、演讲  
25. 自我评价: 为人正直、责任心强、工作认真

1. 姓名: 李四  
2. 性别: 女  
3. 年龄: 30  
4. 职业: 医生  
5. 籍贯: 江苏  
6. 民族: 汉族  
7. 婚姻状况: 未婚  
8. 子女情况: 无  
9. 学历: 本科  
10. 学位: 博士  
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14. 身份证号: 320102199202020002  
15. 住址: 江苏省南京市某某路某某号  
16. 邮编: 210000  
17. 血型: A型  
18. 身高: 160cm  
19. 体重: 50kg  
20. 视力: 正常  
21. 听力: 正常  
22. 语言能力: 普通话、英语  
23. 兴趣爱好: 音乐、绘画、瑜伽  
24. 特长: 钢琴、素描  
25. 自我评价: 性格开朗、乐于助人、专业能力强

# 0 1 2 3 4 5 6

Time	1	2	3	4	5	6
2 PM	1.12	1.12	1.12	1.12	1.12	1.12
3 PM	1.12	1.12	1.12	1.12	1.12	1.12
4 PM	1.12	1.12	1.12	1.12	1.12	1.12
5 PM	1.12	1.12	1.12	1.12	1.12	1.12
6 PM	1.12	1.12	1.12	1.12	1.12	1.12
7 PM	1.12	1.12	1.12	1.12	1.12	1.12
8 PM	1.12	1.12	1.12	1.12	1.12	1.12
9 PM	1.12	1.12	1.12	1.12	1.12	1.12
10 PM	1.12	1.12	1.12	1.12	1.12	1.12















PART IV.

TEST # 4.

TEST OF A COPPER SULPHATE CELL.

PART IV.  
TEST 4.  
TEST OF A COPPER SULPHATE SOLUTION.

## Part IV.

### Test # 4.

In this test a copper sulphate cell was used. The cell was prepared by placing the copper electrode in the bottom of the jar and placing 1.5 lbs. of pulverized copper sulphate or "blue stone" in cell and then filling jar to within .5 inches of the top. The cell was then short circuited for 12 hours to secure a normal condition of operation. The weight of each part entering into the construction of the cell was carefully ascertained.

The current, voltage, and temperature were observed at the same time as these quantities were observed of the other cells.

Curves were plotted showing the value of these quantities with respect to time. The areas of the curves were determined with a planimeter and the average values determined therefrom.

### Calculations and Results.

Weight of zn consumed was 1.472 lbs or 668 gms. The theoretical value of the zn consumed is  $89.4 \text{ amp-hrs} \times 3600 \times .000336 = 108 \text{ gms.}$

The zn evidently consumed by local action was 560 gms., giving an efficiency of 16.2%.

### Cost of Materials.

Cost of zn at 7cts. per lb was 12.9 cts. and cost

Part IV.

Test # 4.

In this test a copper sulphate cell was used. The

cell was prepared by placing the copper electrode in the bottom of the jar and placing 1.5 lbs. of pulverized copper sulphate or "blue stone" in cell and then filling jar to within 5 inches of the top. The cell was then short circuited for 12 hours to secure a normal condition of operation. The weight of each part entering into the construction of the cell was carefully ascertained.

The current, voltage, and temperature were observed at the same time as these quantities were observed of the other cells.

Curves were plotted showing the value of these quantities with respect to time. The areas of the curves were determined with a planimeter and the average values determined therefrom.

Calculations and Results.

Weight of Zn consumed was 1.175 lbs or 527 gms. The theoretical value of the Zn consumed is 1.4 lbs or 635 gms.

$$1.500 \times .000356 = 1.08 \text{ gms.}$$

The Zn actually consumed by local action was 527 gms., giving an efficiency of 16.9%.

Cost of Materials.

Cost of Zn at 70¢ per lb was \$0.8225 and cost

of copper sulphate at 7 cts.per lb. was 10.5 cts,  
giving a total cost of 23.4 cts. for 25.5 watt-hrs.  
or \$9.17 per K.W.Hr.

of copper sulphate at 7 cts. per lb. was 10.5 cts.,  
giving a total cost of \$3.4 cts. for 32.5 watt-hrs.  
or 98.17 per K.W.hr.



C E L L NO. IV.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2PM	.35	1.1	.285		2.57	8
10	.34	1.1	.266		2.75	16
6 AM	.34	1.1	.269		2.75	24
2 PM	.32	1.1	.269		2.78	32
10	.19	.99	.246		3.26	40
6 AM	.314	1.1	.23		3.	48
2 PM	.318	1.1	.227		3.49	56
10	.321	1.1	.233		3.35	64
6 AM	.329	1.15	.22		3.49	72
2 PM	.342	1.08	.235		3.26	80
10	.33	1.08	.222		2.96	88
6 AM	.33	1.06	.244		2.99	96
2 PM	.395	1.08	.26		2.64	104
10	.31	1.03	.25		2.88	112
6 AM	.31	.99	.23		3.05	120
2 PM	.31	1.01	.25		2.84	128



C E L L NO. IV.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
10 PM	.28	1.	.252		2.86	136
6 AM	.30	.96	.225		3.07	144
2 PM	.25	.92	.215		3.12	152
10	.25	.92	.215		3.12	160
6 AM	.24	.91	.214		3.15	168
2 PM	.243	.913	.215		3.02	176
10	.24	.90	.215		3.12	184
6 AM	.22	.89	.22		2.96	192
2 PM	.268	.91	.23		2.82	200
10	.22	.89	.22		2.98	208
6 AM	.22	.88	.22		3.00	216
2 PM	.315	.96	.233		2.92	224
10	.32	.97	.22		2.95	232
6 AM	.31	.965	.23		2.90	240
2 PM	.31	.964	.235		2.90	248
10	.315	.97	.23		2.84	256
6 AM	.29	.95	.228		2.9	264



C E L L NO. IV.

Time	E 1	E 2	I	Densi- ty	r	Hrs.
2 PM	.27	.93	.22		3.	272
10	.28	.94	.22		3.02	280
6 AM	.275	.95	.22		3.06	288
2 PM	.30	.975	.24		2.81	296
10	.29	.96	.22		3.06	304
6 AM	.28	.93	.215		3.03	312
2 PM	.24	.89	.215		3.03	320
10	.21	.88	.22		3.04	328
6 AM	.198	.83	.221		3.	336
2 PM	.26	.83	.2		2.95	344
10	.16	.78	.19		3.26	352
6 AM	.11	.52	.125		3.35	360

THE

Time	W. I.	W. S.	I.	Mean	W.	W. I.
8 PM	24.	25.	25.	24.	24.	24.
10	28.	24.	25.	24.	24.	24.
8 AM	27.	25.	25.	24.	24.	24.
2 PM	30.	27.	24.	24.	24.	24.
10	28.	25.	25.	24.	24.	24.
8 AM	28.	25.	25.	24.	24.	24.
2 PM	24.	25.	25.	24.	24.	24.
10	21.	24.	25.	24.	24.	24.
8 AM	19.	25.	25.	24.	24.	24.
2 PM	22.	25.	25.	24.	24.	24.
10	21.	25.	25.	24.	24.	24.
8 AM	11.	25.	25.	24.	24.	24.



# TABLE 1

Year	Area	Population	Male	Female	Total	Unit
1911	100		50.	50.	100.	MI S
1920	100.8		50.	50.	100.	MI
1930	101.6		50.	50.	100.	MI
1940	102.4		50.	50.	100.	MI S
1950	103.2		50.	50.	100.	MI
1960	104.0		50.	50.	100.	MI S
1970	104.8		50.	50.	100.	MI
1980	105.6		50.	50.	100.	MI S
1990	106.4		50.	50.	100.	MI
2000	107.2		50.	50.	100.	MI S
2010	108.0		50.	50.	100.	MI
2020	108.8		50.	50.	100.	MI S















PART IV.

SUMMATION AND DISCUSSION OF RESULTS.

PART IV.  
SUMMARY AND DISCUSSION OF RESULTS.



## Summation and Discussion of Results.

The highest voltage obtained in this series of tests was 1.832 volts. A greater voltage would evidently have been secured if the temperature had been a little higher.

From a consideration of the cost of materials it will be noted that cell # 2 gave the greatest watt-hour output in the given time. Cell # 1 gave a watt-hr. output 181.2 watt-hrs. at a cost of 39.75 cts. per K.W. Hr. for energy: cell # 2 gave 186 watt-hrs. at a cost of 43.1 cts. per K.W.Hr. for energy: cell #3 gave 178.2 watt-hrs. at a cost Of 43.4 cts per K.W.Hr and the copper sulphate cell gave 25.5 watt-hrs. at a cost of \$9.17 per K.W.Hr.

Referring to the volt-time curve it will be noted that cell # 1 maintained an average current of .2097 amperes for 560 hours, with a voltage variation of 17.2 %. The value of the current was maintained with a variation of only 11.1 % with a temperature variation of 8 deg. Centigrade.

Cell # 2 maintained an average current of 2.88 amperes for 560 hours with a voltage variation, figuring from the time the cell action became stable, of 16.08 % and a current variation of 17.2 % with

## Summation and Discussion of Results

The highest voltage obtained in this series of tests

was 1.832 volts. A greater voltage would evidently have been obtained if the temperature had been 10° higher.

From a consideration of the cost of materials

it will be noted that cell # 2 gave the greatest watt-hour output in the given time. Cell # 1 gave a watt-hour output of 181.7 watt-hrs. at a cost of \$3.72 per K.W. Hr. for energy; cell # 2 gave 186 watt-hrs. at a cost of \$3.10 per K.W. Hr. for energy; cell # 3 gave 17.8 watt-hrs. at a cost of \$3.40 per K.W. Hr. and the copper-aluminum cell gave 32.6 watt-hrs. at a cost of \$3.17 per K.W. Hr.

Referring to the volt-time curve it will be noted

that cell # 1 maintained an average current of .009 amperes for 760 hours, with a voltage variation of 17.3%. The value of the current was maintained with a variation of only 11.1% with a temperature variation of 6 deg. Centigrade.

Cell # 2 maintained an average current of 0.009 amperes for 760 hours with voltage variation, rising from the time the cell action became stable, of 12.8% and a current variation of 17.3% with

a temperature variation of 8 deg.C.

Cell #3 maintained an average current of 2.783 amperes and a potential of 1.305 volts, for a period of 560 hours, with a voltage variation of 17.81  $\%$  and a current variation of 15.8  $\%$ , with a temperature variation of 8 deg.C. This was obtained after the action of the cell had become normal and the resistance properly adjusted.

Cell # 4 did not give a very steady value of voltage or current and was greatly affected by the temperature, while the other three cells were not so greatly affected by changes in temperature. This is readily explained by the fact that the resistance of the potassium chlorate cells varied from a minimum of .106 ohms to a maximum of .246 ohms, while the resistance of the copper sulphate cell varied from 2.57 to 3.35 ohms.

It is evident from a consideration of the cost of materials and watt-output that it costs slightly less to operate the cell at a low rate of discharge than at a high rate of discharge.

From a consideration of the above results it is obvious, that as cell # 2 gave an average discharge of 3.8 watts per second, that it would require 53 copper cells to do the work of one  $KClO_3$  cell.

a temperature variation of  $\pm 1.1^\circ$ .

Cell #3 maintained an average current of 0.745

amperes and potential of 1.105 volts, for operating

560 hours, with average variation of  $17.91^\circ$  and a

current variation of  $13.6\%$ , with a temperature

variation of  $\pm 0.9^\circ$ . This was obtained after an

action of the cell had become normal and the resistance

properly adjusted.

Cell #4 did not give a very steady value of

voltage or current and was greatly affected by the

temperature, while the other three cells were not

so greatly affected by changes in temperature.

This is readily explained by the fact that the resistance

of the potassium chloride cells varied from a

minimum of 100 ohms to a maximum of 2,840 ohms, while

the resistance of the copper sulphate cell varied

from 8.5V to 2.8V ohms.

It is evident from A consideration of the heat of

materials and water-soluble that is totally negligible for

to operate the cell at a low rate of discharge than at

a high rate of discharge.

From a consideration of the above results it is

obvious, that as cell #3 gave an average discharge

of 3.5 watts per second, that it would require 24

copper cells to do the work of one cell #3.

From a final survey of the possibilities of this cell, it appears that there is an extensive field in which the  $\text{KClO}_3$  cell might replace those at present in use, with an enormous saving in cost.

From a final survey of the possibilities of this  
it appears that there is an extensive field in  
which the following will find replacement at present  
in use, with an enormous saving in cost.













